SOUTH

DAKOTA

FISHERIES

LIMITING FACTOR ANALYSIS FOR THE PACTOLA BASIN

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Progress Report
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Limiting Factor Analysis for the Pactola Basin

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I. INTRODUCTION

By all accounts, the quality of the Pactola Basin brown trout fishery has declined since the early 1990’s**.** These 2 miles of stream represent less than 0.5 percent of the perennial coldwater stream habitat in the Black Hills; but represents the largest tailwater trout fishery in the Black Hills and is a very popular destination for flyfishers. In February of 2004, the Black Hills Flyfishers (BHFFs) presented SDGFP a copy of an assessment of the fish habitat prepared by a consulting firm. The report suggested “a pragmatic approach to define limiting factors before implementing remedies is the proper approach.” At this time the BHFFs offered $30,000 of its funds to a cooperative project with the SDGFP to restore the stream habitat and fishery in Rapid Creek in Pactola Basin.

Since the meeting in February of 2004, the fisheries staff in Rapid City and several members of the Black Hills Flyfishers have provided numerous ideas and input as to what could be the limiting factor(s) for this fishery.

The following synopsis is a limiting factors analysis prepared primarily from existing reports (both internal and external) and field data collected in the spring and summer of 2004.

II. HABITAT RELATED LIMITING FACTORS

Are spawning gravels negatively impacted?

Probably not. All electrofishing surveys completed (1988-2004) document a large number of young-of-year and age 1 brown trout (brown trout are fall spawning). (SEE APPENDIX A)

Current fish surveys in 2004 found a small # of age 1 rainbow trout in the upstream most electrofishing survey but none in the electrofishing site downstream. It appears there is a very limited number of rainbow trout (probably spring spawners) successfully spawning in the Pactola Basin.

SDSM&T completed a particle size distribution analysis (APPENDIX B) in the upper reach of the Pactola Basin (upstream of Tamarack Gulch) in the spring of 2004. There does not appear to be a lack of gravel to cobble size material within the riffles. Their study found approximately 50 percent of the substrate in this reach of Rapid Creek is comprised of suitable sized gravel (1-5 cm, Reeves et al., 1991)

At this time SDGF&P staff does not believe there is a need to supplement spawning beds with additional gravel or to purchase equipment to clean the gravel beds.

Vegetation is there too much or not enough?

Areal coverage of aquatic macrophytes is low in the Pactola Basin. A visual estimate of coverage made in July 2004 suggests that less than 10% of the substrate in the reach between the car-bridge to Tamarack Gulch has macrophytes. This is in contrast to anecdotal information that historic coverages perhaps were as great as 30% and found at nearly all locations where pool and/or run substrate and water depth/velocity were suitable for colonization. Aquatic macrophytes provide overhead cover for fishes and suitable habitat for macro-invertebrates. Cover/Substrate as used in the Habitat Quality Index (Binns 1979) were among the eight attributes out of twenty-two measured that were significantly correlated with trout standing crop. Loss of the aquatic macrophytes in the Pactola Basin following the record high flow years of 1996-1999 (USGS 2004) likely had a detrimental effect on fish cover and macro-invertebrate abundance. Recolonization of the potentially suitable habitats in the Basin has been slow due to lack of recruitment of fine substrates conducive to macrophyte colonization due to the location of the reach immediately below the Pactola Reservoir. Low phosphorus levels in the discharge water from Pactola also may be contributing to slow recolonization of aquatic macrophytes. Transplanting macrophytes from other reaches of Rapid Creek or other streams is possible; however, suitable substrate must be available to realize success as well as protection from physical disturbance/wash-out during initial establishment (G.Larson, SDSU, personal communication 2004). *Ranunculus sp*. (white-water crowfoot) is the most common aquatic macrophyte now found in the basin and in many downstream reaches of Rapid Creek.

Would increasing the complexity of the reach improve the fishery? How can this be accomplished?

Yes, increasing habitat complexity would provide increased potential for holding cover, overwinter holding water, and conditions suitable for aquatic plant colonization; features that are now likely found in inadequate supply and are negatively impacting the fishery and angler satisfaction. Cover is defined as anything that provides protection from predators or ameliorates adverse conditions of stream flow and/or seasonal changes in metabolic costs (Western Division AFS 1983). Deepening pool habitat via sediment removal, placement of object cover using rocks or large woody debris, and improving conditions suitable for aquatic macrophytes or planting aquatic macrophytes are all potential actions to incrementally improve habitat in the basin reach. Incremental improvement will provide cover for small numbers of fish as well as provide additional fishing locations for anglers. Low flows typical of the October-March time period limit the potential for habitat improvement by increasing the diversity and complexity of instream cover.

How does the flow regime impact habitat quality?

Pactola Reservoir releases are managed by the US Bureau of Reclamation and US Army Corps of Engineers (flood pool releases). Releases are scheduled to provide municipal and irrigation water under contracts to the City of Rapid City and the Rapid Valley Irrigation District. A 6000 acre-foot pool of water is managed by the Bureau specifically

for fishery purposes. Use of this water occurs in conjunction with the SD GFP and other resource agencies. This pool of water can be used to supplement releases scheduled from the reservoir during low flow periods when the reservoir pool elevation and corresponding indexed flow release is deemed inadequate to maintain fisheries for a short period of time (perhaps one winter season). The annual low flow period normally extends from October through March. No provisions for spring flushing flows are currently scheduled as part of normal reservoir operations. Typical low flow releases are between 15-25 cfs. Releases ramp up in March and again in April at the onset of the irrigation season and continue through the irrigation season at the end of September. Typical summer irrigation releases are between 40-100 cfs depending on the year and irrigation needs. The City of Rapid City requests water releases during the irrigation season to make up for any water taken from the stream for municipal purposes. Municipal water needs outside the irrigation season are met entirely from wells or springs today; therefore no water is generally requested October through March. Releases during this period of the year are indexed to reservoir water surface elevations and a 3-year running trend of water yield to Pactola with consideration given to the minimum amount of water deemed necessary to keep the Rapid Creek fishery alive. A high priority is given to storing water in Pactola and its sister reservoir Deerfield which are managed together to supply the necessary irrigation and municipal water needs during the summer.
This management scenario presents little room for discretionary use of reservoir releases for fishery management purposes. Fish habitat enhancement must be conducted within the normal range of flows subject to the extremes of high and low releases.

The last period of extended high flows took place during 1995-1999 when record setting high flows during the months of May-August occurred with corresponding high winter flows. The years with the highest mean monthly flows during this period were 1998-99. The peak daily discharge during this period took place in 1996 when a release of 450 cfs was recorded June 7, 1996. Peak daily releases over 400 cfs took place each year from 1996-1999. These releases generally correspond to the maximum flows modeled by SDSMT (450 cfs) that indicated that most bed gravels and cobbles would be mobilized throughout the reach. Flows of this magnitude also demonstrated their ability to affect considerable bank erosion (SDSMT 2004). Incremental evaluation of lower flows and their ability to mobilize streambed material is incomplete at this time, however, due to the shape of the channel and relationship between the ability of the water to move materials and the hydraulic radius it is likely that little effective bed mobilization will take place at flows less than bankfull. If this is accurate, it means that redistribution of in-place sediment cannot be accomplished using programmed releases from the reservoir.

The last high flow period (1995-99) did, however, have considerable impact on the streambed and sediment distribution in the reach. The sub-reach showing the most dramatic impact from the high flows is downstream from the USGS weir and upstream from the first walk-bridge across the stream. In this reach, fish habitat features installed in 1987-89 designed to constrict the channel during low flow periods functioned to concentrate flow energy from the high releases, generating degradation of the channel with a corresponding bed level adjustment that migrated upstream to the weir. This bed level adjustment was followed by a corresponding bank height adjustment along the entire reach. This process is ongoing as evidenced by the bank scarp on either side of the stream upstream of the walk-bridge and the isolation/desiccation/death of woody riparian vegetation in some locations; in particular along the left bank of the reach. Sediment generated during this cycle likely was dropped in depositional areas in the “duck pond” area and the backwater near the channel block installed to recover the oxbow below the “duck pond”. Other sub-reaches with the basin reach show signs of local degradation and corresponding upstream bed level adjustment as well, but are shorter and less dramatic than the sub-reach below the USGS weir.

The predominant fish habitat features installed during the 1987-89 period were current deflectors and rock vortex type pools. With the exception of the peak flow of 286 cfs recorded in June 1993, no high flows took place to work on these structures with no corresponding bedload mobilization taking place until 1995-1999. No opportunity for large scale hydraulic work therefore took in during the seven years immediately following installation of the features designed to constrict stream channel cross section during low flows or for much local scour to occur. Some minor scour occurred and some overbank fill on the new structures was removed during the seven years prior to high flows. During those years, instream habitat diversity was enhanced. Low winter flows, in particular, were more confined in some sub-reaches pre-1995 than following the high flows. The affects of the change in channel cross-section were masked when high winter flows (1997-2001) were necessary. Following a resumption of more typical winter flows in 2002 the impacts of the changes affected to the channel cross-section and sediment distribution become evident on holding cover and corresponding fish population numbers.

The range of variability in flow releases from Pactola (15- 450 cfs) and typical seasonal variability (15-100 cfs) creates a difficult situation for installation of permanent channel constriction features or to overall modify the width-depth ratio. More success is likely with smaller scale objects such as the rock placements (1997) that provide for local scour/holding cover but do not have the ability to affect sub-reach dynamics during the inevitable high flow events. These features will work to create fish cover without the likelihood of large scale impacts during high water. Woody debris in addition to rocks would add object cover that would also develop local scour.

The annual winter flow is set by the Bureau of Reclamation in early October. The release is tied to reservoir pool elevations as well as the precipitation trend for the preceding 3 years. The minimum release schedule is as follows:

Date	**Pool elevation**	**Release**
Year round	above 29,000 AF	20 cfs
10/1-4/15	below 29,000 AF	15 cfs*
4/15-10/1	below 29,000 AF	20 cfs

* An additional volume of water (up to 4 cfs) may be released to offset ice build up if deemed necessary and reservoir levels permit

The release established in October is normally maintained through the winter period to allow for least amount of change in wetted perimeter. Fluctuations in wetted perimeter would potentially subject redds to desiccation or freezing if too optimistic a release were begun in October and then lowered mid-winter due to less than anticipated inflows to the reservoir. Fluctuating releases during the winter also contribute to ice build up and potential for damage to private property adjacent to the stream between Pactola and Rapid City. If extreme winter conditions develop with abnormally cold temperatures contributing to high volumes of ice build-up, the 6000 AF fishery pool of water can be used to supplement flows during the cold period to offset icing. The 6000 AF pool of water managed by the Bureau of Reclamation can also be used to supplement winter flows during periods when the reservoir storage is below 29,000 AF, but once the pool of water is used it must be replenished to allow the minimum release schedule shown above to resume. Winter releases during a prolonged drought with the 6000 AF fishery pool depleted revert to the Definite Plan Report schedule of 7 cfs (10/1-4/15) if the reservoir storage is below 29,000 AF.

SEE APPENDIX C for Historic Streamflow Information

How does the gradient change downstream of Tamarck influence the dynamics of the stream and fishery above and below?

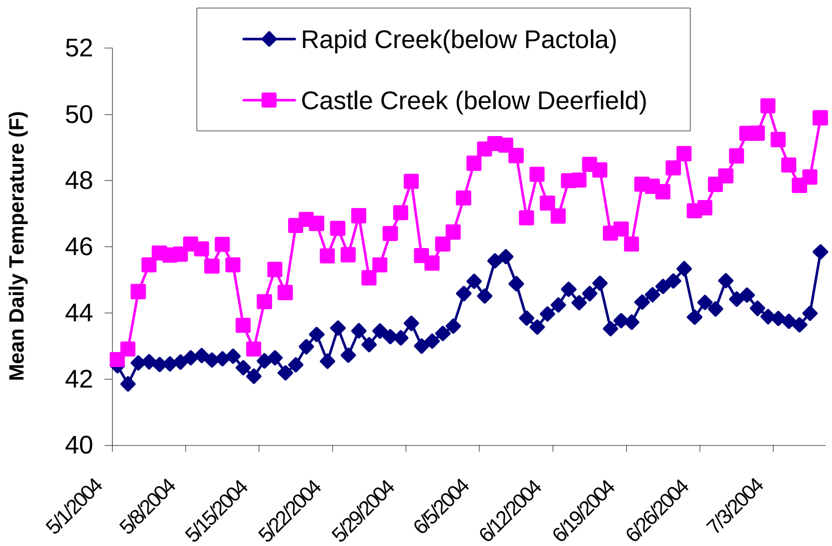
There are differences in substrate composition stream bed profile, and channel cross-section, just downstream of the old parking lot at Tamarack Gulch from most reaches upstream. Cumulative substrate composition and comparative channel cross-sections are shown in the following figures (SDSMT 2004, SEE APPENDICES B). These changes also contribute to the reach downstream of the walk-bridge near Tamarack being used less by fisherman; as evidenced by the extent of streamside trail development and the focus of habitat evaluation by the Black Hills Flyfishers (2004 map mark-up). Based on the evidence of the substrate composition and channel cross-section it appears that the current velocities would be generally higher in this reach. Less pool and run habitat is available in this reach than upstream, creating more of a "pocket water" fishery.

III. PRODUCTIVITY RELATED LIMITING FACTORS

Is poor water quality a limiting factor?

Pactola reservoir is the water source for "Pactola Basin". Pactola is the coldest and purest surface water source in South Dakota and is used by the City of Rapid City as a drinking water source. There is no evidence suggesting there has been an acute or chronic violation of SD water quality standards. Unlike Deerfield and Sheridan (the 2 other large reservoirs in the Black Hills), Pactola does not stratify. Recording temperature gauges were placed in the stream in 2004 and have shown that it is highly unlikely stream temperatures ever approached thermal maxima for brown or rainbow trout.

During the summer months stream temperatures are colder in this reach of stream than any other creek in the Black Hills. From May 1st –July 3rd of 2004 maximum daily temperatures did not exceed 55° F as far downstream as the trestle. The summer temperatures are probably well below the optimal for brown trout growth (Erickson hopes to have a bioenergetics analysis completed shortly that compares maximum growth rates of brown trout in the Pactola Basin, Castle Creek below Deerfield, and Rapid Creek as it flows through Rapid City).



Phosphorus is the limiting nutrient in most aquatic systems. Most of the trout streams in the Black Hills are low in phosphorous (less than 0.05 mg/L). When ferrous iron and oxygen are present (the conditions we have about Pactola) the iron and phosphorous form a precipitate and thus the phosphorous is no longer available as a nutrient. The high concentration of iron in the water upstream of Pactola limits the amount of phosphorous in Pactola.

2004 Water Quality Sampling in the Black Hills

Water	Site Letter	Site Designation	Date	Total Phos. (mg/L)	Total Iron (mg/L)
Castle Cr.	A	Bridge Above Deerfield	28-Apr-2004	0.044	0.224
Castle Cr.	A	Bridge Above Deerfield	4-Jun-2004	0.026	< 0.050
Castle Cr.	A	Bridge Above Deerfield	6-Jul-2004	0.021	0.050
Castle Cr.	B	Below Deerfield Outlet	28-Apr-2004	0.012	0.058
Castle Cr.	B	Below Deerfield Outlet	4-Jun-2004	0.037	< 0.050
Castle Cr.	B	Below Deerfield Outlet	6-Jul-2004	0.018	0.114
Deerfield	A	near dam	4-Jun-2004	0.013	NA

Deerfield	B	Castle inlet	4-Jun-2004	0.024	NA
Pactola	A	near dam	4-Jun-2004	0.019	NA
Pactola	A	near dam	6-Jul-2004	0.010	NA
Pactola	B	Jenny Gulch	4-Jun-2004	0.024	NA
Pactola	B	Jenny Gulch	6-Jul-2004	0.012	NA
Rapid Cr.	A	Above Pactola dam	28-Apr-2004	0.011	0.640
Rapid Cr.	A	Above Pactola dam	4-Jun-2004	0.022	0.310
Rapid Cr.	A	Above Pactola dam	6-Jul-2004	0.010	0.539
Rapid Cr.	B	Bridge below Pactola Dam	28-Apr-2004	0.012	< 0.050
Rapid Cr.	B	Bridge below Pactola Dam	4-Jun-2004	0.023	< 0.050
Rapid Cr.	B	Bridge below Pactola Dam	6-Jul-2004	< 0.010	< 0.050
Sheridan	A	near dam	4-Jun-2004	0.034	NA
Sheridan	A	near dam	6-Jul-2004	0.017	NA
Sheridan	B	Spring inlet	4-Jun-2004	0.093	NA
Sheridan	B	Spring inlet	6-Jul-2004	0.015	NA

Note: the total phosphorous values for Rapid Creek within Rapid City for June and July, 2001 were similar

(range was 0.010 - 0.030 mg/l)

Would there ever be a likely oxygen sag in the reach due to macrophyte die back?

Biological oxygen demand (BOD) is probably very low in this reach of stream. Oxygen sag has not been demonstrated as a problem in the past. In 2001 and 2002 SDGF&P installed 5 continuous D.O. monitoring systems in Rapid Creek within the city limits of Rapid City where nutrients and densities of algae and macrophytes are higher, and stream temperatures are warmer. D.O. values below 6 ppm (the SD criteria for a coldwater fishery) occurred less than 0.1% of the time.

It's highly unlikely that low oxygen levels are limiting this fishery. Erickson and Kenner were unable to document an oxygen sag issue in Rapid Creek as it flows through where nutrient levels stream temperatures are much higher and temperatures are Rapid City

How does water temperature affect trout growth and survival?

Two fish tagged in the stilling basin on June 15th, 2000 were captured in the upstream electrofishing site October 2nd, 2001 (the better part of 2 growing seasons). Both of these fish grew very slow and demonstrates how the low temperatures and low productivity affect these fish. This also demonstrates brown trout do move in and out of the Pactola stilling basin.

June 15th, 2000	268 mm	192 grams
October 2nd, 2001	297 mm	254 grams
Growth	29 mm	56 grams
June 15th, 2000	487 mm	820 grams
October 2nd, 2001	491 mm	799 grams

Growth	4 mm	-21 grams

What has changed in terms of possible food sources from Pactola since the early 1990's?

In the late 1980's and early 1990's Dick Ford (former GFP fisheries biologist in Rapid City) monitored the mysis (a freshwater shrimp) population in Pactola Basin. Mysis were abundant and probably provided some forage for the trout in the Pactola Basin. In 2000 and 2001, (Holcomb 2002) failed to capture mysis in his sampling as part of his study to quantify the productivity of Pactola Reservoir.

Anecdotal reports by several flyfishers were that amphipod (scuds) were prevalent in the early 1990's and flies imitating scuds were very effective. Hans Stephenson reports that he and Dave Gamet did some kick sampling from the stilling basin downstream to through the "bend pool" in 2002 and 2003 and saw many scuds and fish this pattern regularly in the upper reach of Pactola Basin (Personal communications with Hans Stephenson on 09-July-2004).

What do we know about the diatom (*Didymosphenia geminata*) in Rapid Creek and could it be impacting the trout fishery?

This diatom was first brought to the attention of SDGF&P in May of 2002. Several Homeowners and an angler called to report huge volumes of a white substance between Johnson Siding and Thunderhead Falls. At first glance it appeared to be plastic, toilet paper or fiberglass insulation. One landowner adjacent to Rapid Creek reported he had filled a 50-gallon drum with the stuff but had only cleaned up 30 feet of stream. The SDDENR was contacted and one of their biologists (Robert Smith) identified it as a naturally occurring diatom. This diatom forms huge mats that in some areas coat the entire stream bottom. Currently, it is prevalent from Pactola Dam downstream through Hisega.

According to Dr. Max Bothwell (an internationally recognized diatom expert from the National Water Research Institute Pacific Biological Station in British Columbia), "Didy" is a fairly common freshwater diatom that very rarely forms such large mats. The only places he has heard of these types of large mats forming are in streams are on the eastern side of Vancouver Island in Canada, Iceland, New Zealand, and the Pyrenees Mountains of Spain. A graduate student working for him (John Deniseger) in 1989 first noted a small patch of it in a stream on Vancouver Island the size of a sheet of plywood. A year later it covered approximately 4 km of stream. Since then, it shows up regularly in many of the streams on Vancouver Island. Dr. Bothwell shared the following observations and knowledge.

He suspects "Didy" is a common diatom cold water streams but that it thrives under the following conditions

Low phosphorous. Typically the productivity of stream is limited by the amount of phosphorus. “Didy” appears to thrive in low productivity waters and probably has a mechanism that allows it to recycle phosphorous.

It thrives on high light conditions. Stream that develop these mats typically flow E-W and the north side of the streams (where there is less shading) have higher densities of “Didy”.

Unlike many other diatoms it thrives on UV light. Thus it usually found in shallow water. Dissolved organic carbon within the water column limits UV penetration so he suspects this is one reason it thrives in low productivity waters.

It shows up more often on regulated streams than unregulated streams and typically in years with low winter flows (in British Columbia). In wet years he suspects high flows uproot the mats.

In years when “Didy” densities become large (2-3 inches thick is not uncommon) they see a decrease in stonefly and mayfly densities and increases in chironomids (small midges often associated with poor water quality).

In years with “Didy” outbreaks on Vancouver Island citizens quit swimming in the streams and users who depend on this water as a drinking water source often report disagreeable taste or odor to the water.

There is some correlation between the size of the salmon runs and the “Didy” outbreaks on Vancouver Island. He was quick to point out that he is not sure of the mechanism. It may be that “didy” expands when salmon runs are small (salmon carcasses are a major source of phosphorous and nutrients). It may also be that the “Didy” are limiting the salmon by limiting its food source. Dr. Bothwell says the silica capsules can be seen in the water if you look at the water through a microscope. He suspects these silica capsules could cause some gill irritation but the limited field bioassays he conducted were inconclusive.

The following link provides a good synopsis of “Didy” in British Columbia.

http://wlapwww.gov.bc.ca/wat/wq/didy_bcstrms.html

How does the invertebrate population in Pactola Basin compare with other streams in the Black Hills? Is it adequate?

In July 2004 , Jeff Shearer looked through his invertebrate samples from Pactola Basin and Hisega. Based on that information and his observations while sampling Rapid Creek, Jeff believes the invertebrate community in the Pactola Basin is higher in diversity and lower in density than most stream reaches below impoundments. Typically the invertebrate communities below impoundments are dominated by filter feeders, especially black fly larvae and hydropsychid caddisflies, which are filtering seston produced in the reservoir. He observed very few black fly larvae and no hydropsychid caddisflies in the Pactola Basin (probably attributing to Pactola's unproductive nature). He did observe Baetid mayflies, several stonefly families (Chloroperlidae, Capniidae), Brachycentrid caddisflies, Tipulidae (cranefly larvae), Chironomidae, and scuds (Gammaridae) in the Pactola Basin. He thinks there are there are other species as well, but it would require a more detailed analysis of his samples. Baetid mayflies are among the most abundant aquatic insects in BH streams. Baetids were more abundant in the Basin than above near Silver City, but not nearly as abundant as you would find in Spearfish Creek. Chloroperlidae were common while Capniidae were rare in the Basin, He did not observe either of these families at Silver City. Usually stoneflies become less abundant as stream size (and water temp) increases. The lower, "maintained" water temps in the Basin may be why Chloroperlidae were more common than he'd expected for that stream size. Brachycentrid caddisflies are quite common in BH streams, but family diversity in the Basin is lower than he typically finds. Tipulidae and Gammaridae were about as abundant as he had observed on Whitewood Creek or Spearfish, certainly most so than at Silver City. Chironomidae were common like most streams (Jeff can't elaborate on diversity at this time without more detailed ID work).

At Hisega there was an increase in invertebrate diversity. Riffle beetle larvae and adults (Elmidae) and Heptageniid mayflies were present. Riffle beetles are fairly common in the Black Hills but Heptageniid mayflies are rare. As in the Basin, Baetid mayflies, Chloroperlid stoneflies, Brachycentrid caddisflies, and Chironomidae were present and common. He did not observe Tipulidae or Gammaridae in the two samples examined.

Overall, Jeff thinks Rapid Creek in the Basin ranks about "middle of the road" as far as invertebrate productivity and diversity go for Black Hills streams. The Basin is noticeably more productive than Rapid Creek near Silver City or Castle Creek at Castle Peak CG and similar to Rapid Creek at Hisega. But Rapid Creek is probably an order or two less in magnitude when compared to the productivity of Spearfish Creek (just imagine if Spearfish had a cobble / gravel bottom throughout its course!), Castle Creek (prior to NF Castle Cr confluence), or Whitewood Creek. Jeff hasn't haven't looked at Spring or French Creeks enough to compare them. If Pactola Reservoir were more productive, he would expect invertebrate densities to increase in the Basin by several orders of magnitude.

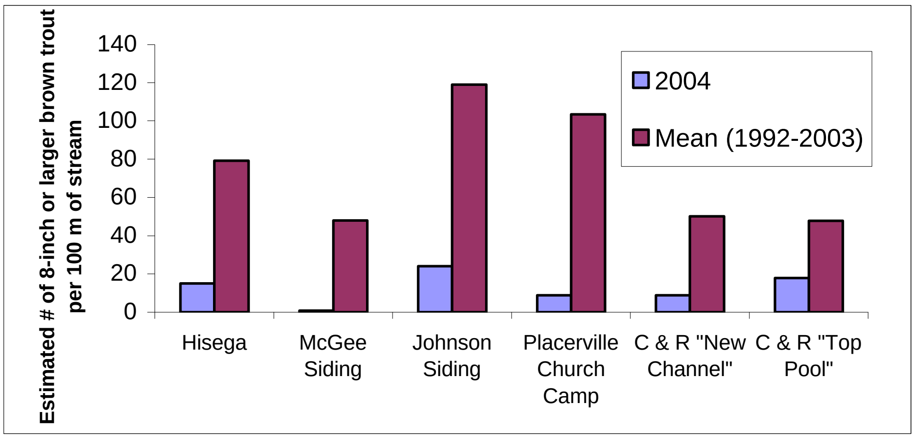
Could weed spraying within the basin be a limiting factor?

Noxious weeds are sprayed by the Pactola dam tender. Chemicals used are Rodeo and Curtail. Weeds are primarily sprayed in the vicinity of the groin and toe drain. Rodeo is used near water as it is labeled for aquatic use. Curtail is used in upland areas. Target weed is primarily Canada Thistle. Little treatment has been pursued for the last two years (2002-03) (personal communication Dave Lucas 7-13-04). Based on this information it is unlikely that noxious weed spraying has had an impact on the aquatic macrophyte population in the reach of Rapid Creek in the basin area.

IV. MANGEMENT RELATED LIMITING FACTORS

What is the current status of the trout fishery in the Pactola Basin?

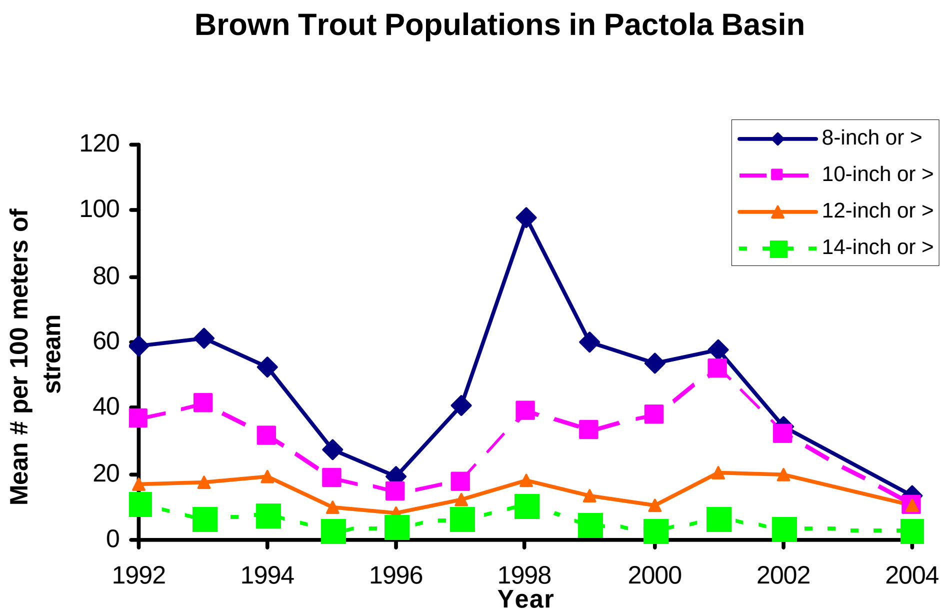
The densities of 8-inch or larger brown from Hisega upstream to Pactola Dam are significantly lower than they have been since 1992. Densities are approximately 15% of the norm since 1992. The densities of fry and age 1 fish are similar but there are very few age 2 to ~age 6 fish.



The two most recent length-frequency distributions for each of the sites are provided in Appendix C.

What has been the historic trend of the trout fishery in the Pactola Basin?

There have been some cyclical fluctuations in numbers of fish but the number of fish longer than 8-inches has dropped to an all time low in 2004.



Are grazing and trespass cows still an issue?

No, grazing was eliminated by the USFS approximately 2000. Only trespass cows now infrequently “visit” the basin.

If the magic fix were found today and implanted immediately, how long before we would expect to see an increase in the # of large brown trout?

Currently the brown trout in Rapid Creek from Hisega upstream to Pactola are either very old (probably 6^+ years) or very young (fry and 1-year). During the next several years the number of large fish will continue to decrease and the it will probably take more than 4 years before we start recruiting significant number of new fish to the 14-inch or large size class.

What is the history of the special regulations in the Basin?

1991 -- Portion of Rapid Creek from the foot bridge at Placerville Church Camp upstream to the 1st bridge immediately below Pactola Dam was designated Catch-and-Release.

1994 – Small section of Rapid Creek from the outlet of the stilling basin to the 1st bridge immediately below Pactola Dam was added to the Catch-and-Release area.

1997 – Stilling basin below Pactola Dam is added to the Catch-and-Release area.

Could high angler use be limiting this fishery?

Although this reach of stream is a catch-and-release fishery, each time a fish is captured there is additional stress and some anglers may be using poor handling techniques that increase the mortality rate. Hooking mortality for trout caught on flies is estimated to be less than 4.5% (Schill and Scarpella, 1997). SDGF&P does not know if this is a significant limiting factor for this fishery.

Is poaching a problem?

Certainly there is some poaching occurring and bait containers are observed but the GFP staff believe enforcement efforts in the last several years have significantly improved compliance since the early 1990s when the anglers felt the fishery was in better shape.

Is the osprey a major predator?

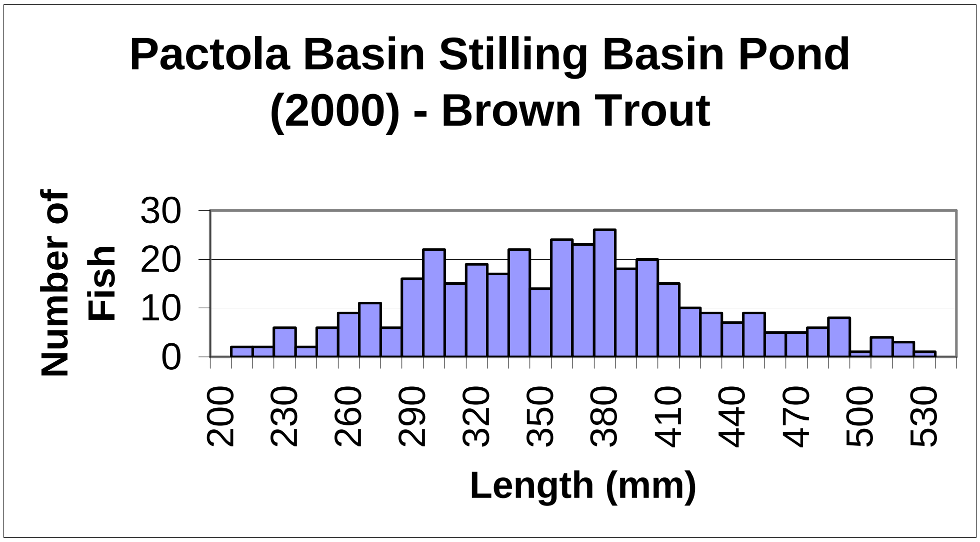
No, the ospreys have been nesting below Pactola Dam since 1991 (Dowd, 1992). Although anglers have observed the osprey “taking” fish from the settling pond, there is no evidence to suggest they prey on fish in the stream. Dam tender Dave Lucas has not observed an osprey feeding on fish in the stream (Lucas, Personal Communications 2004).

Could the installation and of the new outlet structure at the dam be a problem? If so how?

In 2000, SDGFP elctrofished the stilling basin below Pactola Reservoir for 4 nights. All trout longer than 8-inches were tagged with unique serial #’s. Our Jolly-Seber population estimate was 1,918 (s.e. = 315) trout. The species distribution was as follows:

94% brown trout
3% brook trout
4% rainbow trout

Anecdotally, anglers report catch rates are much higher for rainbow trout (40-60%) than they showed up in our survey (4%).



Anglers see numerous brown trout in the fall with fungus on them. Is disease an issue?

Disease is probably not an issue. The white fungus (*Saprolegnia* spp.) on brown trout in the Rapid Creek drainage from Pactola Dam downstream through Rapid City is commonly observed October-December each year and is a secondary fungal infection and is assumed to be related to spawning stress. There is no treatment for this disease since the fungus naturally occurs in the watershed.

On 19-November-2002, SDGF&P in cooperation with the USFWS-National Fish Health Laboratory in Bozeman, Montana a wild fish health assessment was conducted on the brown trout population from Placerville Church Camp upstream to Pactola Dam. Sixty fish were collected and tested for the following pathogens:

Reinbacterium salmoninarum
Yersinia ruckeri
Aeromonas salmonicida
Edwardsiella ictaluri
Edwardsiella tarda
Infectious Hematopoietic Necrosis Virus
Infectious Pancreatic Necrosis Virus
Oncorhynchus Masou Virus
Myxobolus cerebralis (“whirling disease”)
Viral Hemorhagic Septicemia Virus

All results from this fish health screening were negative.

When did SDGF&P discontinue stocking the Pactola Basin?

The SDGF&P stocking records are incomplete. However 1991 was the last time the reach Rapid Creek from Johnson Siding to Pactola Dam was stocked (and then only at the pond at the Placerville Church Camp). Keith Wintersteen (assistant hatchery manger at Cleghorn Springs SFH) reports that he is unaware of any trout being stocked in the Pactola Basin since he started working (1986) at Cleghorn Springs SFH.

Larry Ferber (retired hatchery manager at CSFH) remembers stocking the stilling pond below Pactola Dam with rainbow trout in the 1980's and possibly the early 1990's. There were no records in our stocking database document these stockings (personal communication, 13-Jul-2004).

Is fish passage over the USGS weir an issue?

The USGS weir at station #06411500 has been in place since October 1962. Fish populations in the basin reach of Rapid Creek have been subject to preclusion of passage on a regular basis for over 40 years. It is not believed that recent declines in numbers of trout in the basin can be correlated with any recent impacts of the weir.

Can angler expectations be met with a wild brown trout fishery?

Not in the next 4 or more year unless a stocking program is implemented. Multiple year classes of brown trout (2-5 year-olds) are missing from this fishery.

How are other tailwater fisheries managed for quality in the adjacent states of Wyoming and Montana?

Tailwater fisheries in Wyoming and Montana such as the "Miracle Mile" downstream of Seminoe Reservoir on the North Platte, Gray Reef; downstream of Alcova Reservoir on the North Platte, Bighorn River below Boysen Reservoir and the Bighorn River below Bighorn Lake all share similarities to the Pactola Basin below Pactola Reservoir in South Dakota. These outstate tailwater fisheries also have factors that differentiate them from the Pactola Basin.

The overriding similarity is that all systems mentioned are "tailwater" fisheries; they are located downstream of run-of-the-river impoundments on major stream systems in the respective states. Angler expectations in these tailwater fisheries are high due to the perennial nature of flow and the near year-round accessibility due to lack of ice formation in portions of each tailwater immediately below the outlet.

Factors that sort the outstate tailwaters from the Pactola Basin are scale and productivity of impounded and source waters. Scale refers to annual volume and channel morphometry. Productivity refers to the ability of the source water and impoundments upstream from the tailwaters to cycle nutrients to the tailwater reach and ultimately into fish production.

Retired Wyoming fisheries management chief, Bob Wiley, in a 1993 paper published in the North American Journal of Fisheries Management (13:160-170) eloquently states a similar philosophy as SDGFP has espoused in the 1993 Black Hills Stream Management Plan. The following quote is worth reading;

"Fishery management decisions are value judgments consisting of trade-offs between opposing options. Options for the management of trout are complete dependency on natural reproduction, judicial use of hatchery and wild fish, or intensive and extensive use of hatchery fish. We prefer the first two, even though there may be vexing social and biological problems with balancing the wild with the hatchery product. Balance between what Wyoming can provide naturally in the way of trout and can be stocked safely and cost-effectively does not depend solely on responding to public demands. Trout stocking programs can generate further pernicious demand, resulting in increased and unnecessary dependence on hatchery trout, because people come to expect planted trout. Successful management programs address public interests as well as the biology of the fish so that angler expectations are at least partly met (Wiley 1989) by foresighted management programs (McFadden 1969)."

This philosophy is evident in the management of the previously mentioned Wyoming and Montana tailwaters as all but the Bighorn River below Bighorn Lake require use of hatchery fish, in particular rainbow trout, to strike a balance between the expectations of anglers and biology.

POSSIBLE ACTIONS:

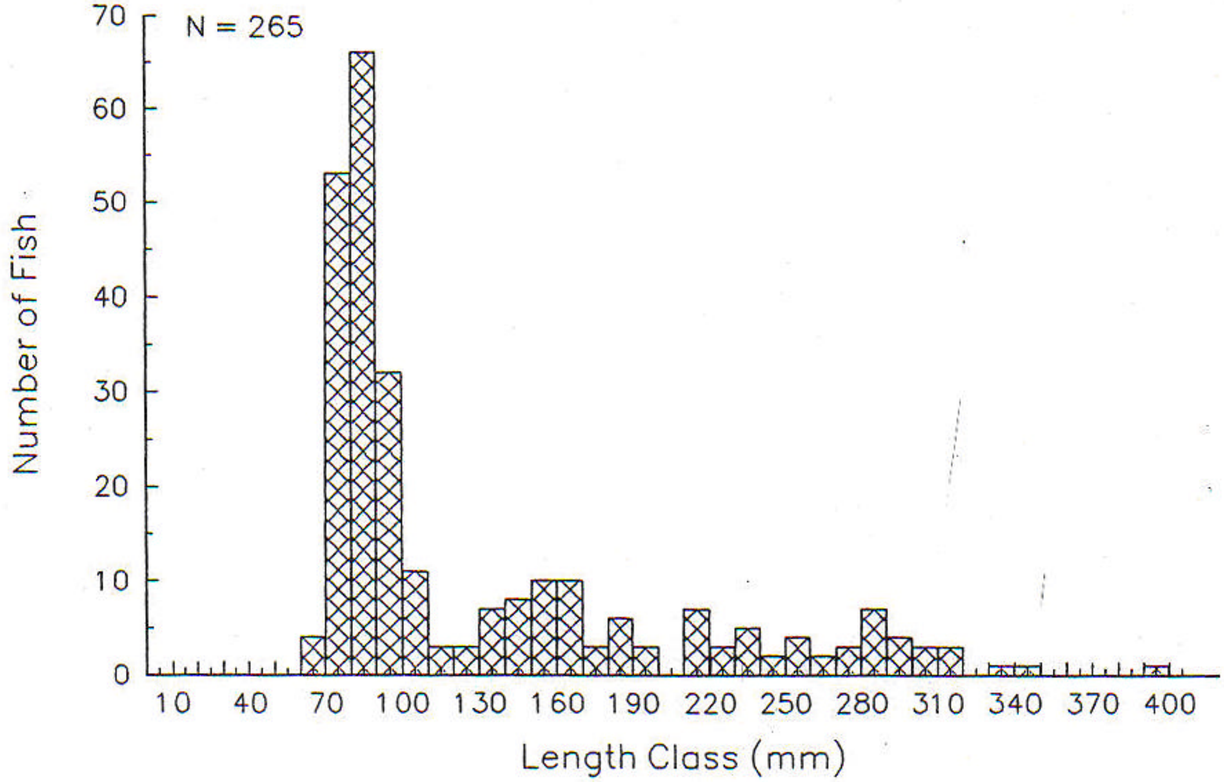
- Increase complexity by adding additional woody debris in the form of large trees
- Increase habitat complexity by adding additional rock clusters
- Dredge 3 pools containing fine sediments
- Install an exclosure around willow bundle rehab area to allow willows to protect the bank. Remove in 2 years
- Try to reestablish macrophytes in several pools
- Stock a small number of large rainbow trout annually (~25 initially and ~10 per month?)

- Continue to monitor fish populations annually to determine if BNT fishery is recovering and discontinue stocking of rainbow trout when several strong year classes of brown trout exist.

- Supplement the stream with leaf debris in the fall to provide organic material to stimulate invertebrate growth, possibly provide unfavorable nutrient conditions for “Didy” diatom, and provide a source of material for aquatic macrophytes to establish roots.

APPENDIX A

APPENDIX A



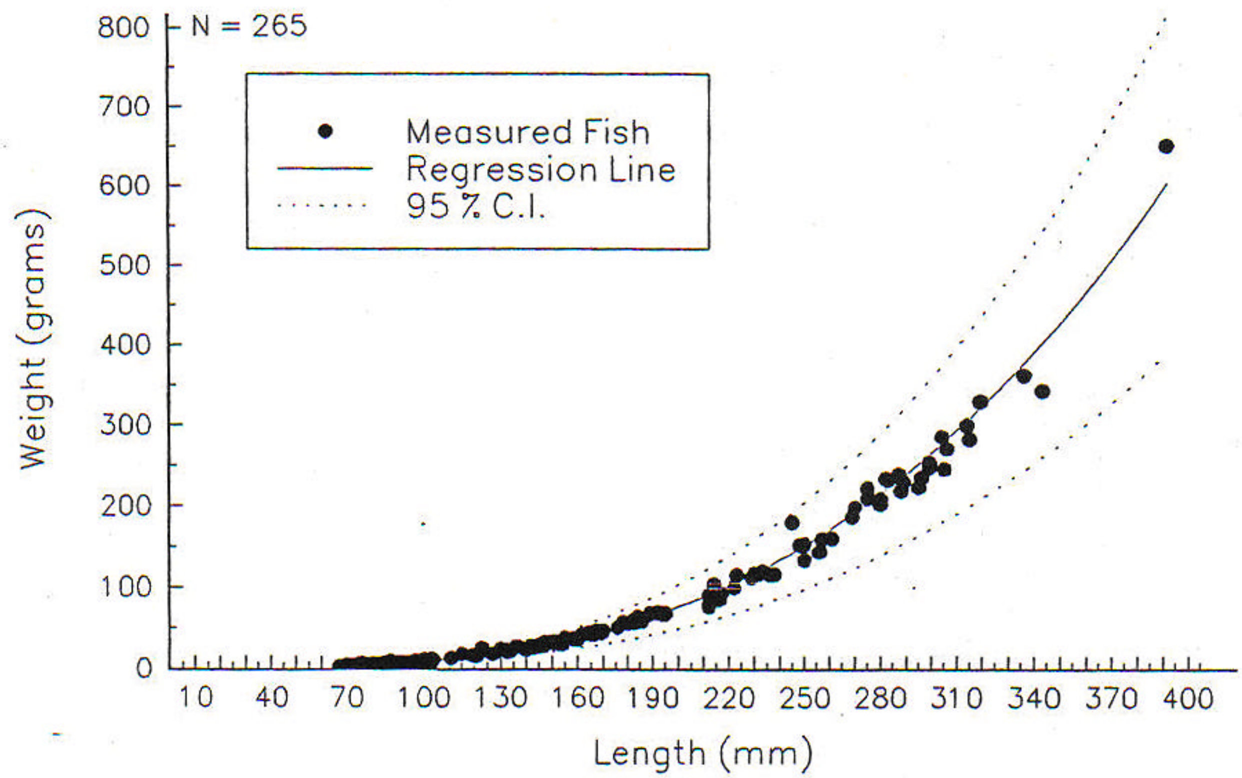


Figure Brown Trout length–frequency and length–weightregression at Rapid Creek, Site 15 (100m), McGee Siding on 27 SEP 1993.

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APPENDIX A CONT.

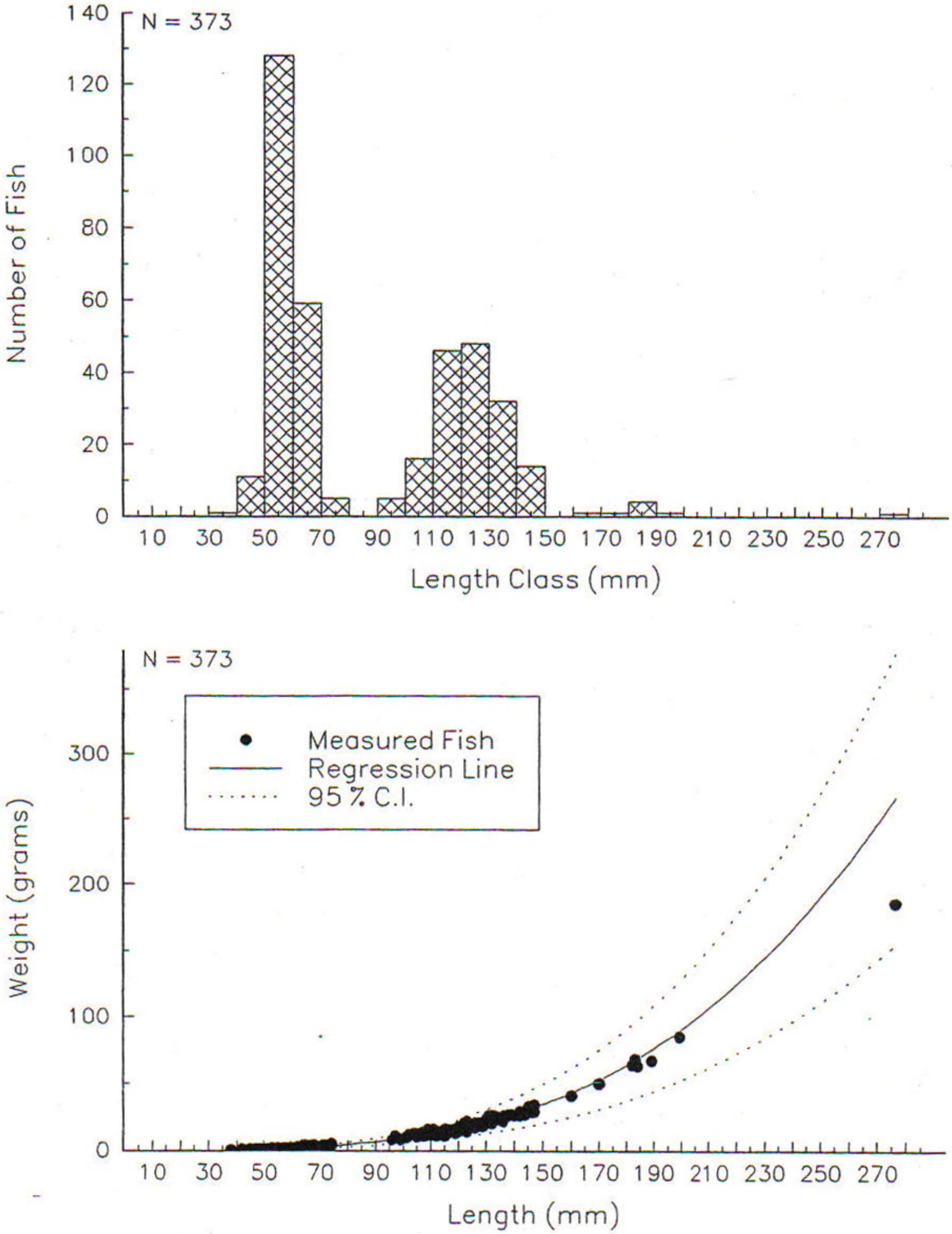

Figure Brown Trout length–frequency and length–weightregression at
Rapid Creek, Site 15 (100m),
Mc Gee Siding
on 24 JUN 2004.

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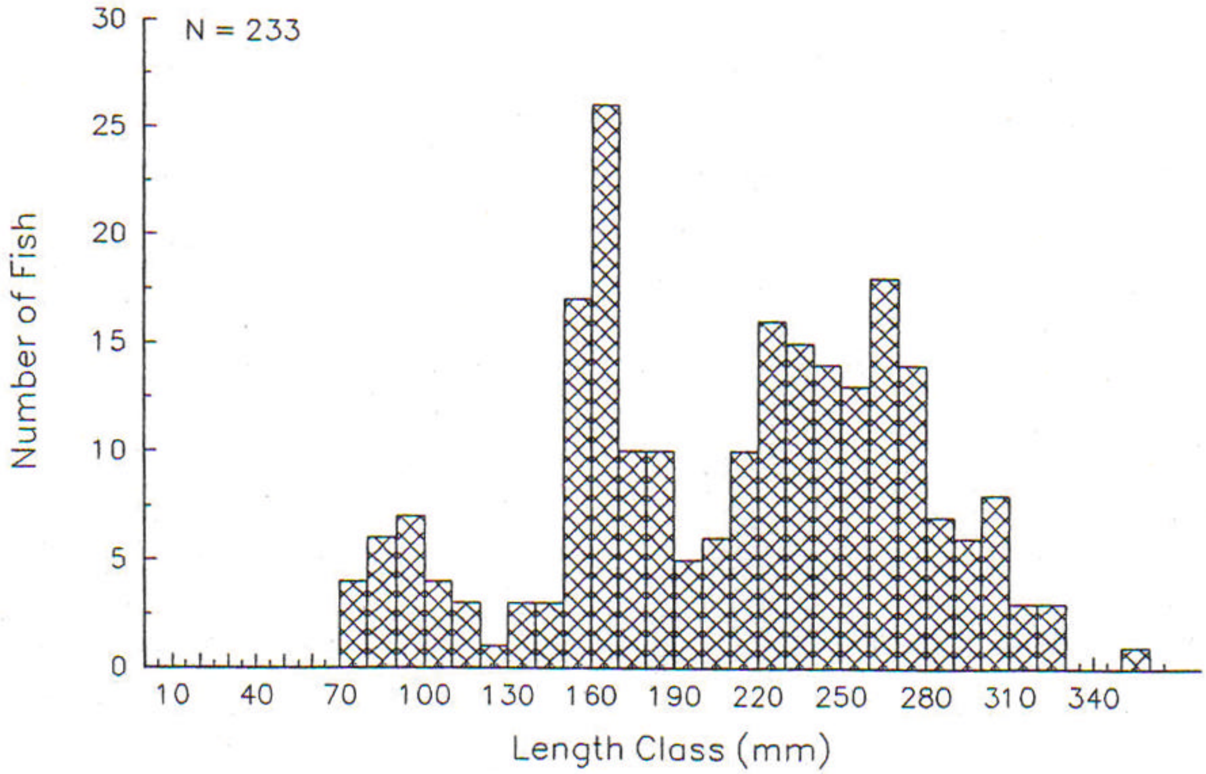
APPENDIX A CONT.



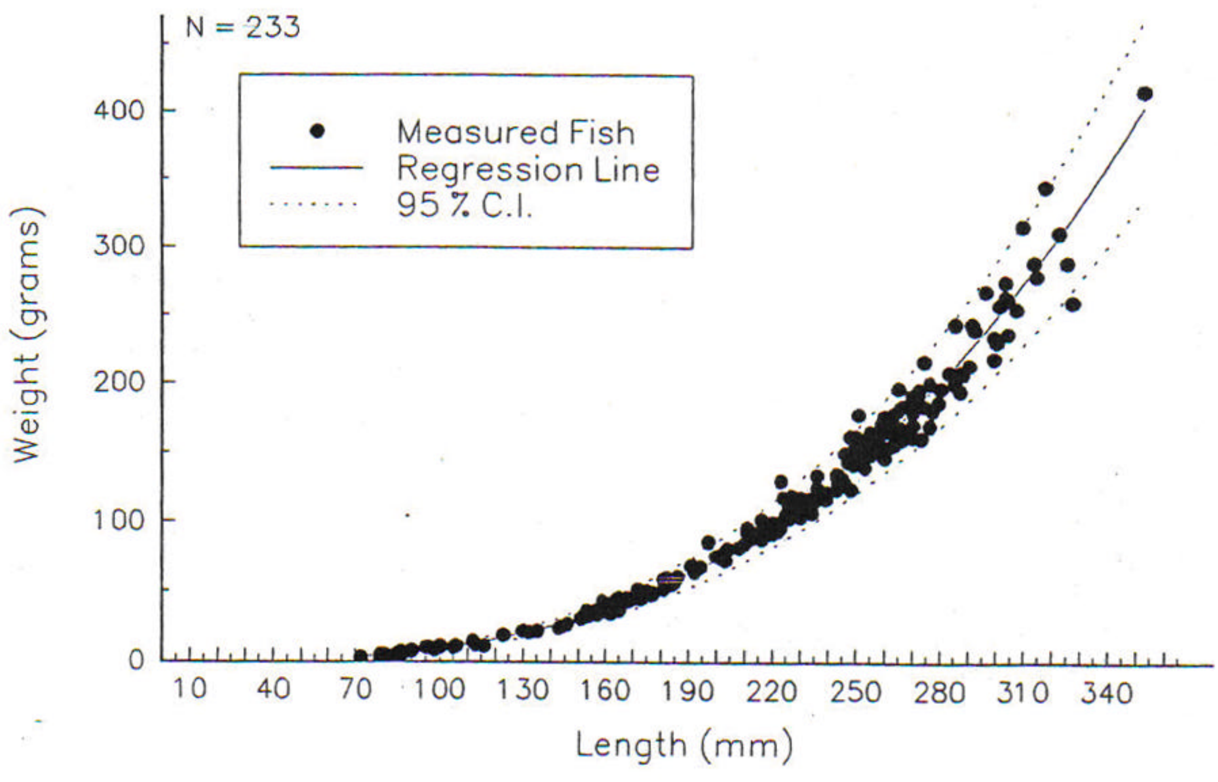


Figure Brown Trout length–frequency and length–weightregression at
Rapid Creek, Site 16 (100m),
Below Johnson Siding (1984 site 25)
on 20 OCT 1999.

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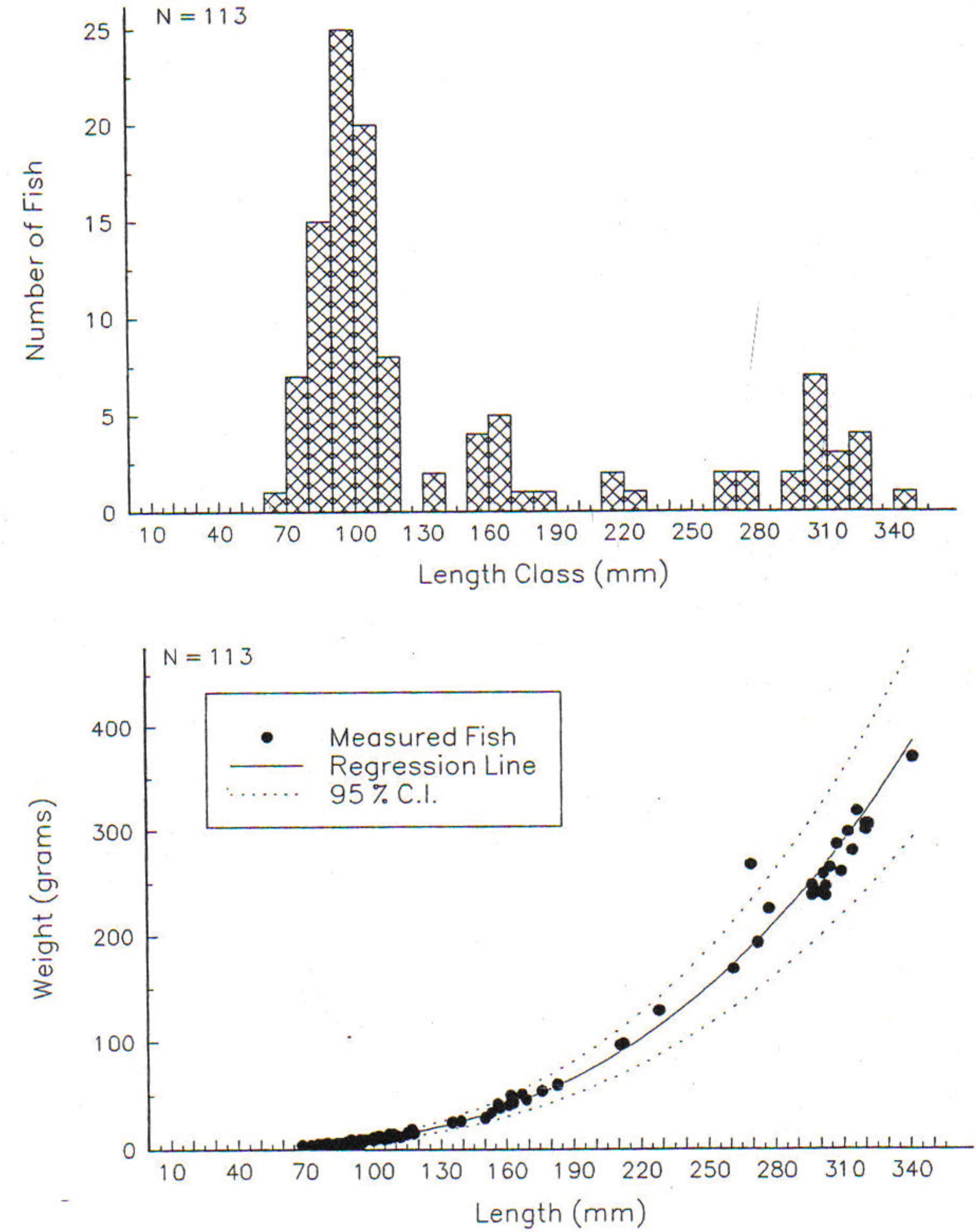

Figure Brown Trout length–frequency and length–weightregression at
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Below Johnson Siding (1984 site 25)
on 09 JUN 2004.

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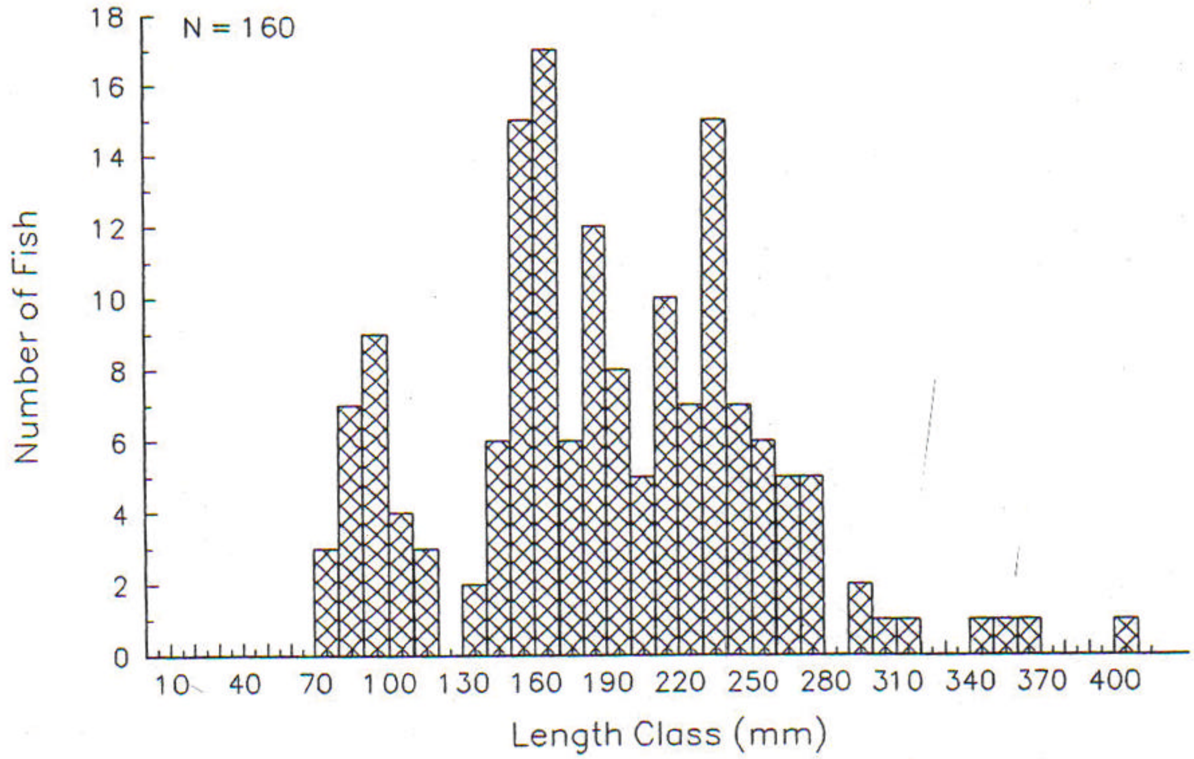

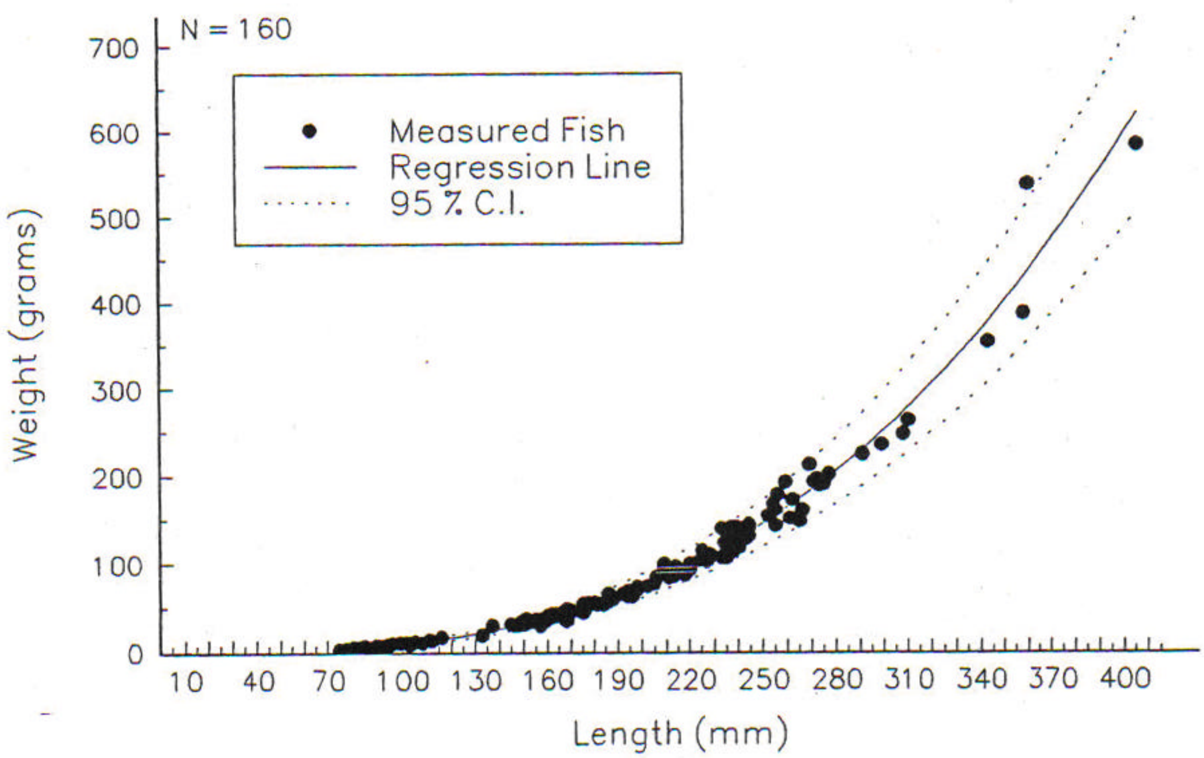

Figure Brown Trout length—frequency and length—weightregression at
Rapid Creek, Site 17 (100m),
Below Placerville Camp Dam
on 18 OCT 1999.

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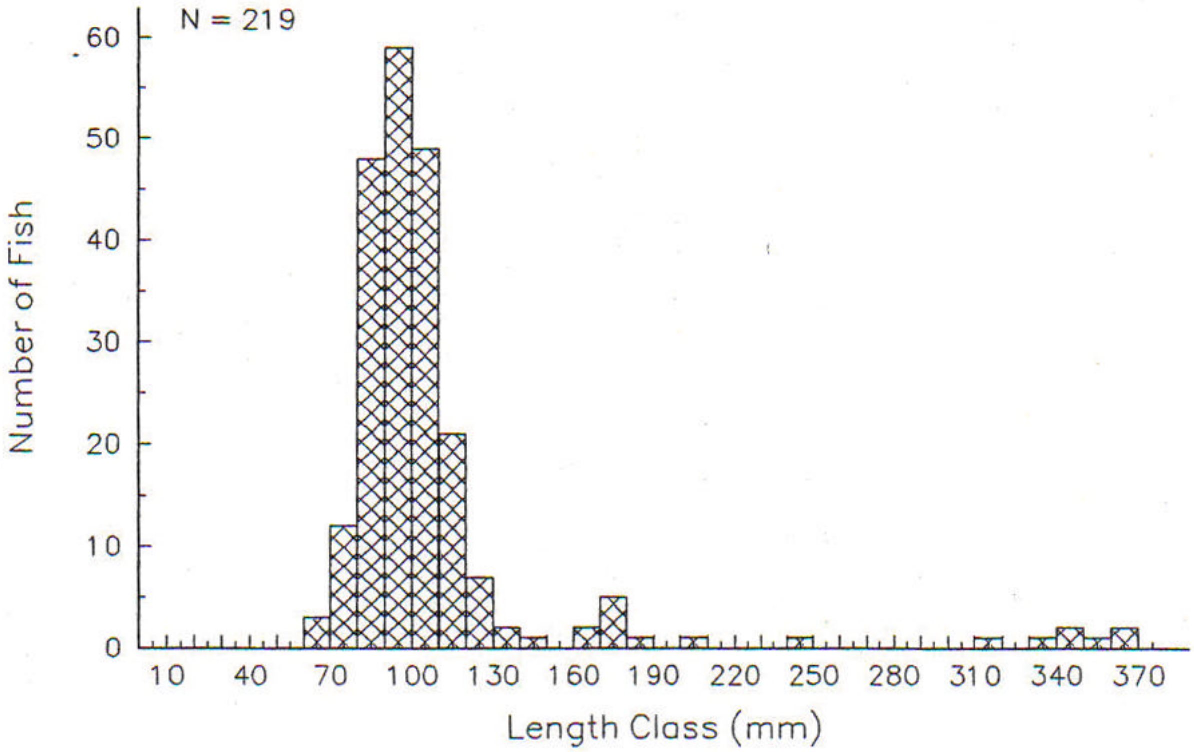
APPENDIX A CONT.



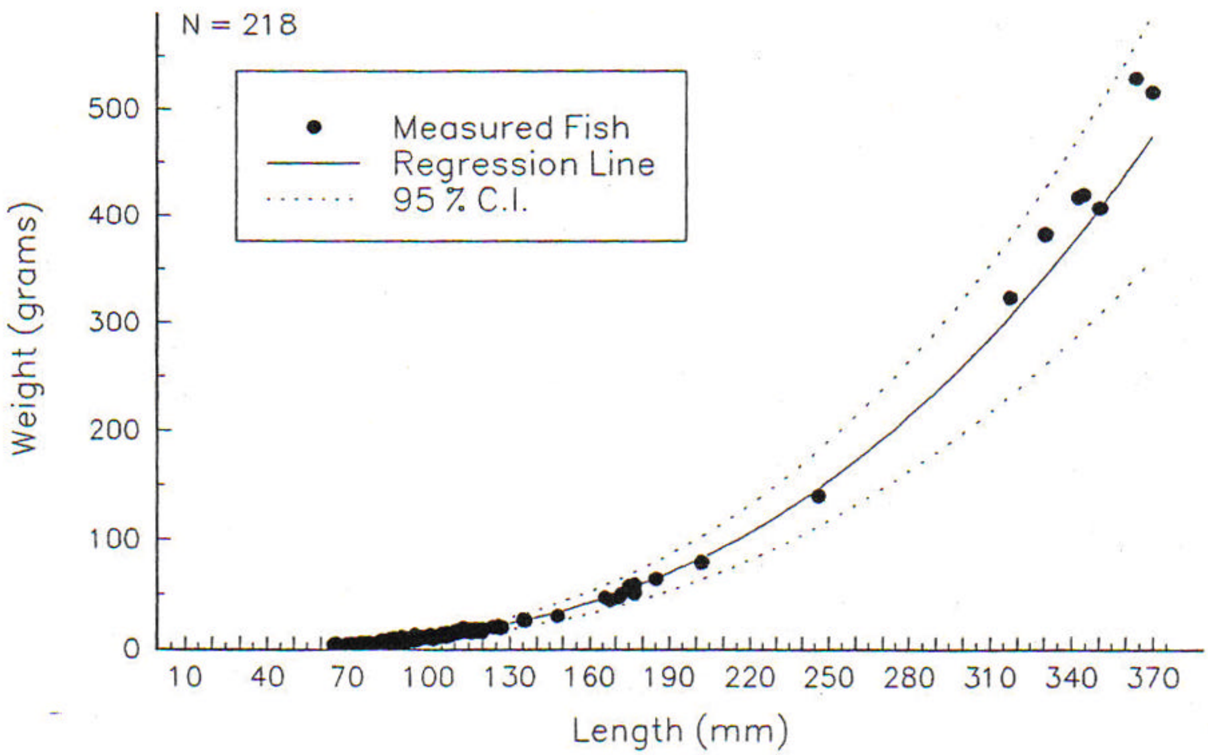


Figure Brown Trout length–frequency and length–weightregression at
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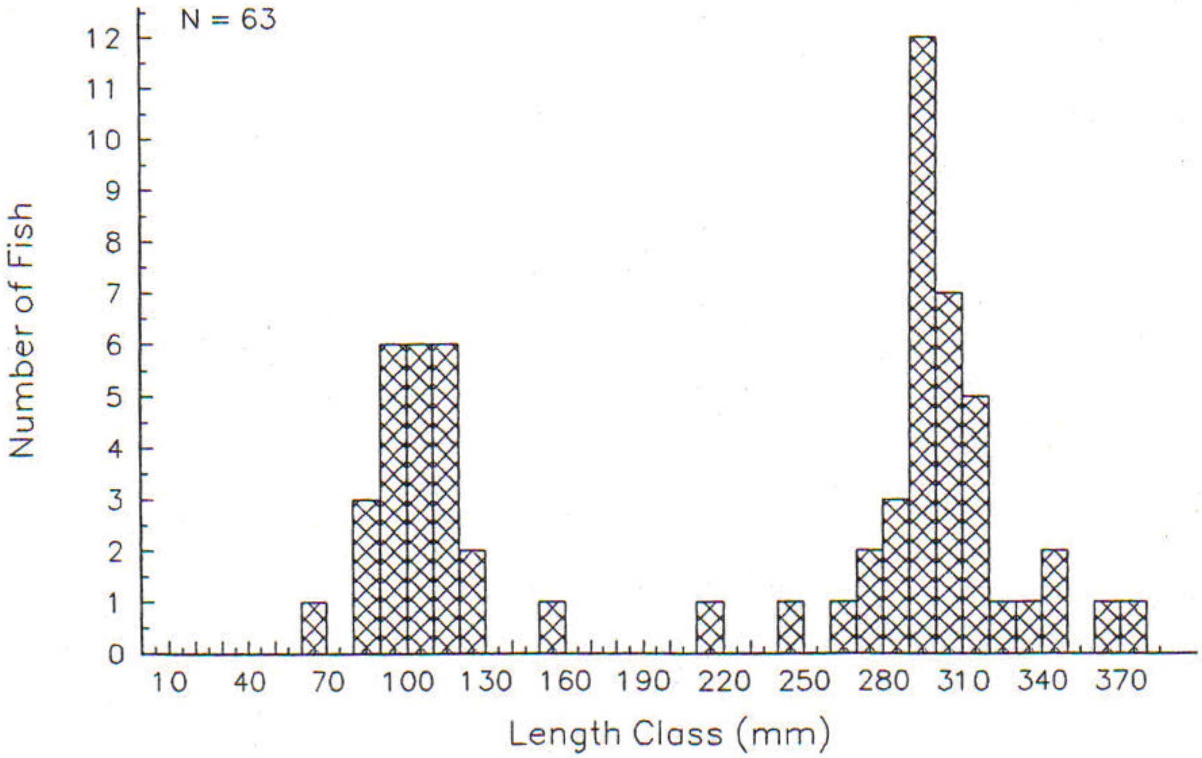
Below Placerville Camp Dam
on 24 JUN 2004.

printed 28jun04 13:58



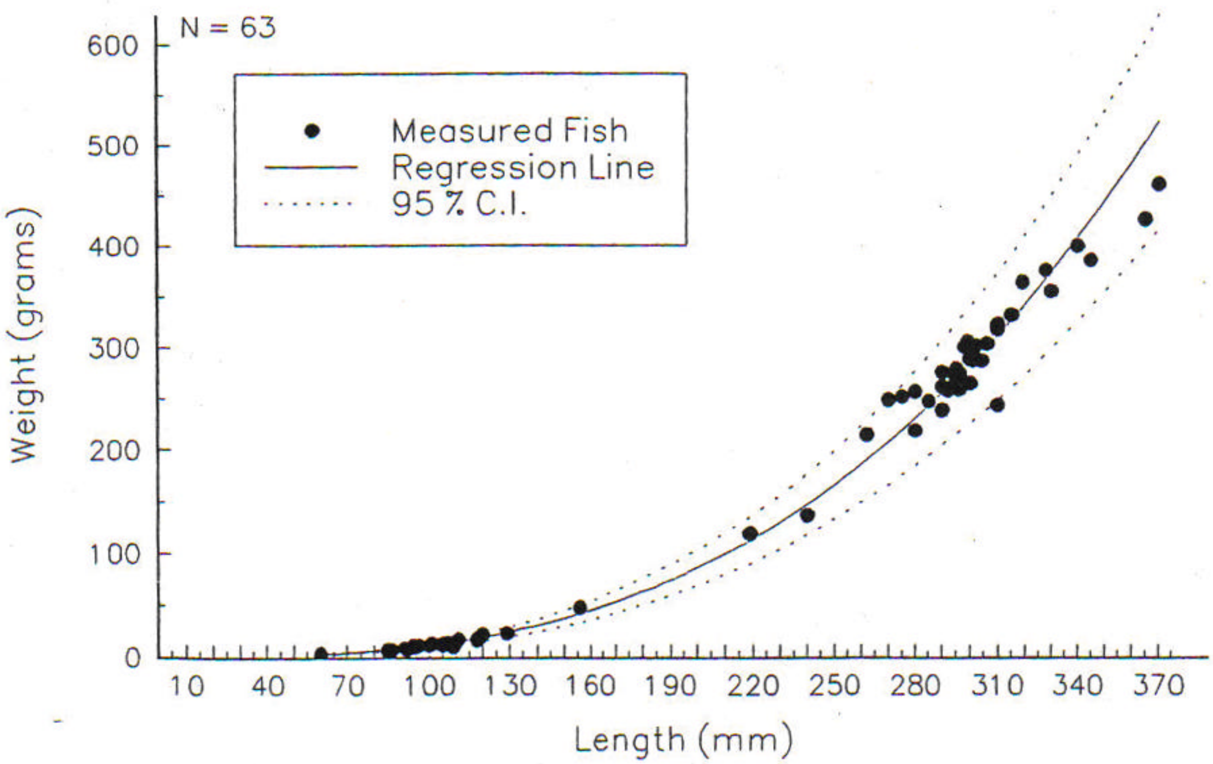
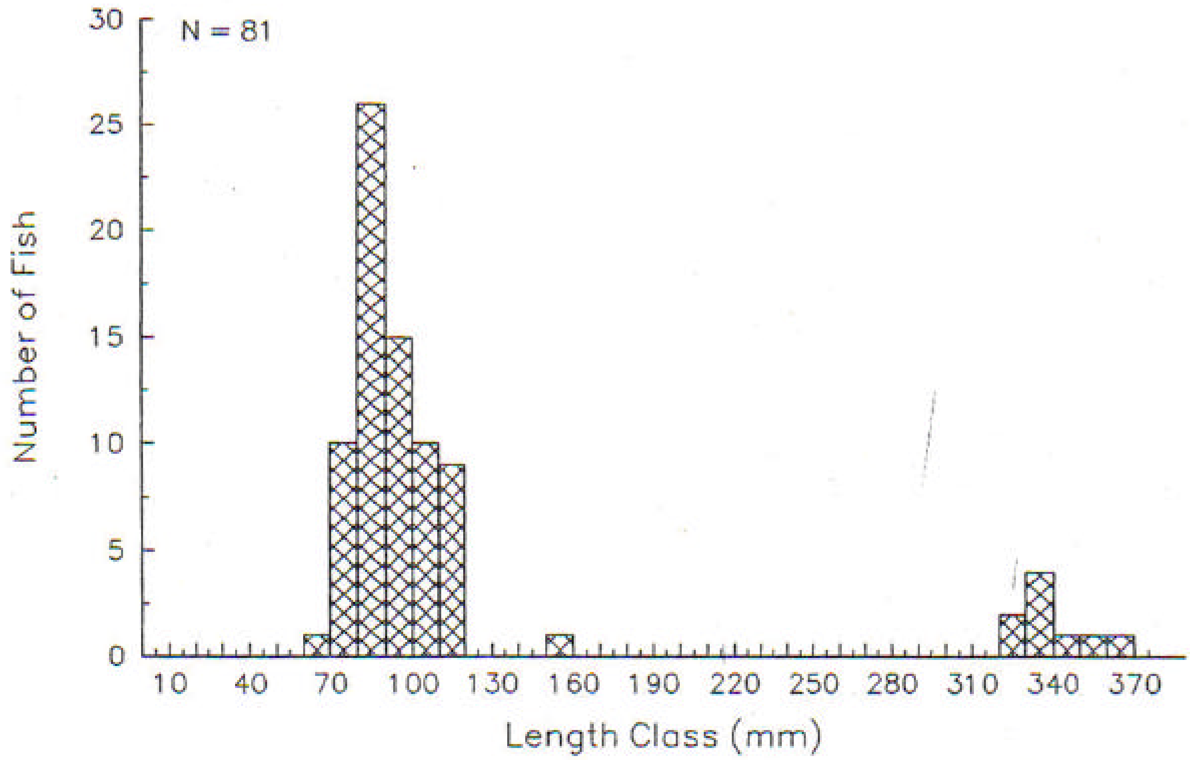


Figure Brown Trout length–frequency and length–weightregression at Rapid Creek, Site 8 (100m), Pactola Basin (new channel) on 25 OCT 2002.

printed 15jul04 10:55



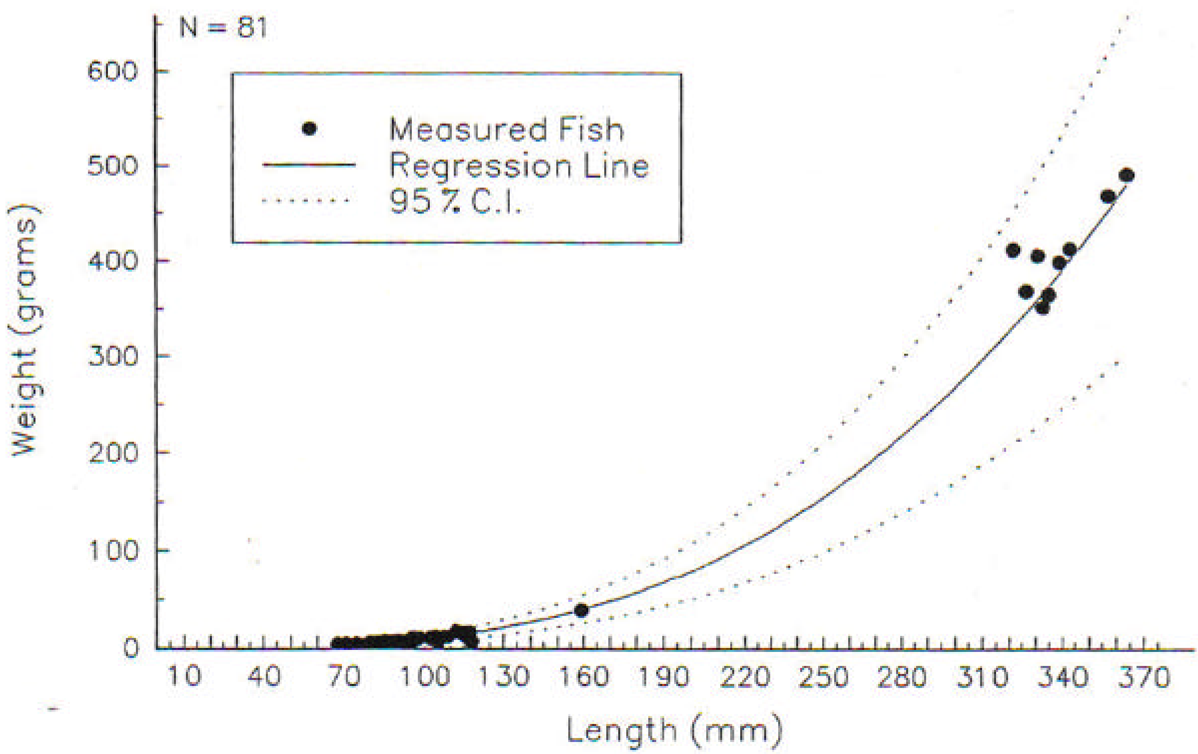
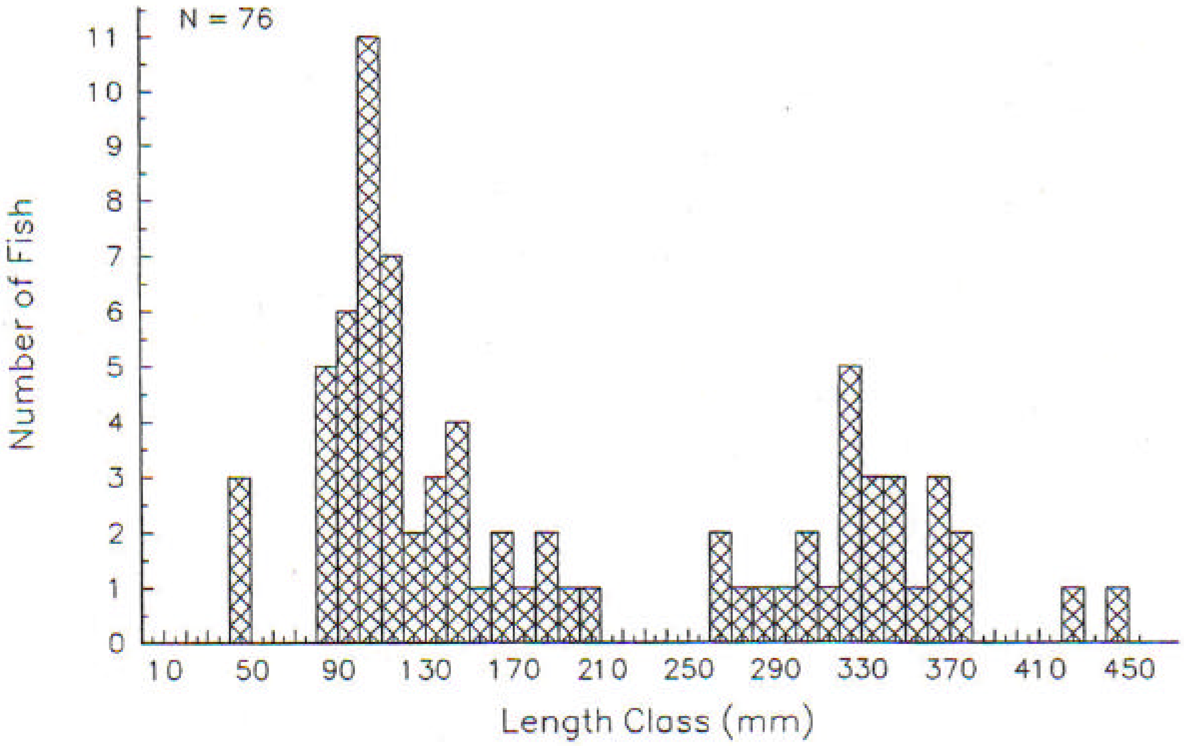


Figure Brown Trout length–frequency and length–weightregression at
Rapid Creek, Site 8 (100m),
Pactola Basin (new channel)
on 07 JUL 2004.

printed 07jul04 15:33

APPENDIX A CONT.



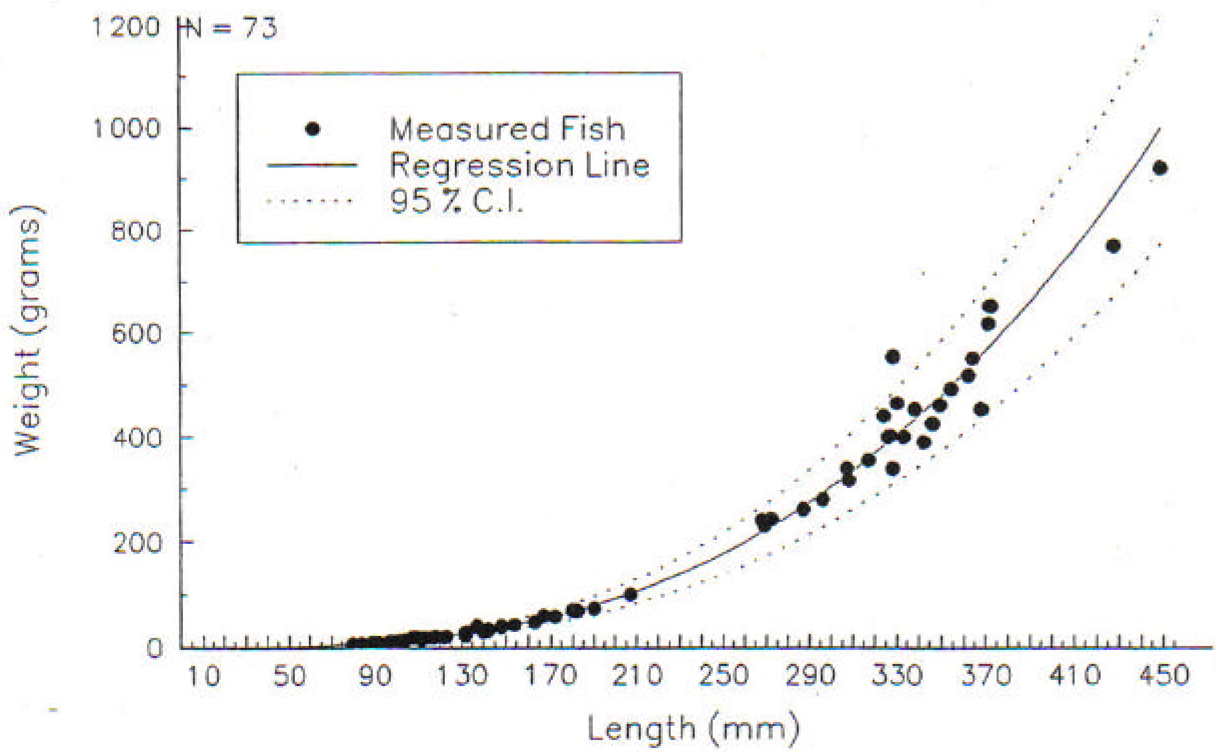


Figure Brown Trout length–frequency and length–weightregression at Rapid Creek, Site 9 (100m), Pactola Basin (immediately below USGS bridge) on 23 SEP 2002.

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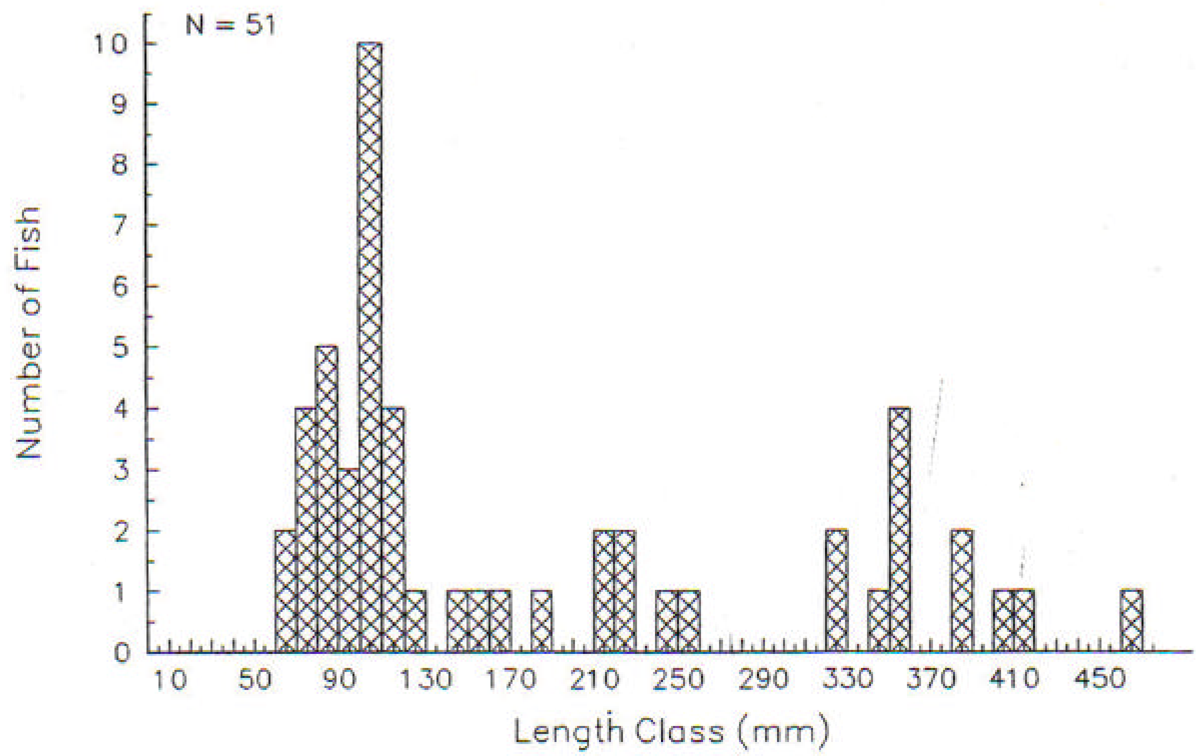
APPENDIX A CONT.



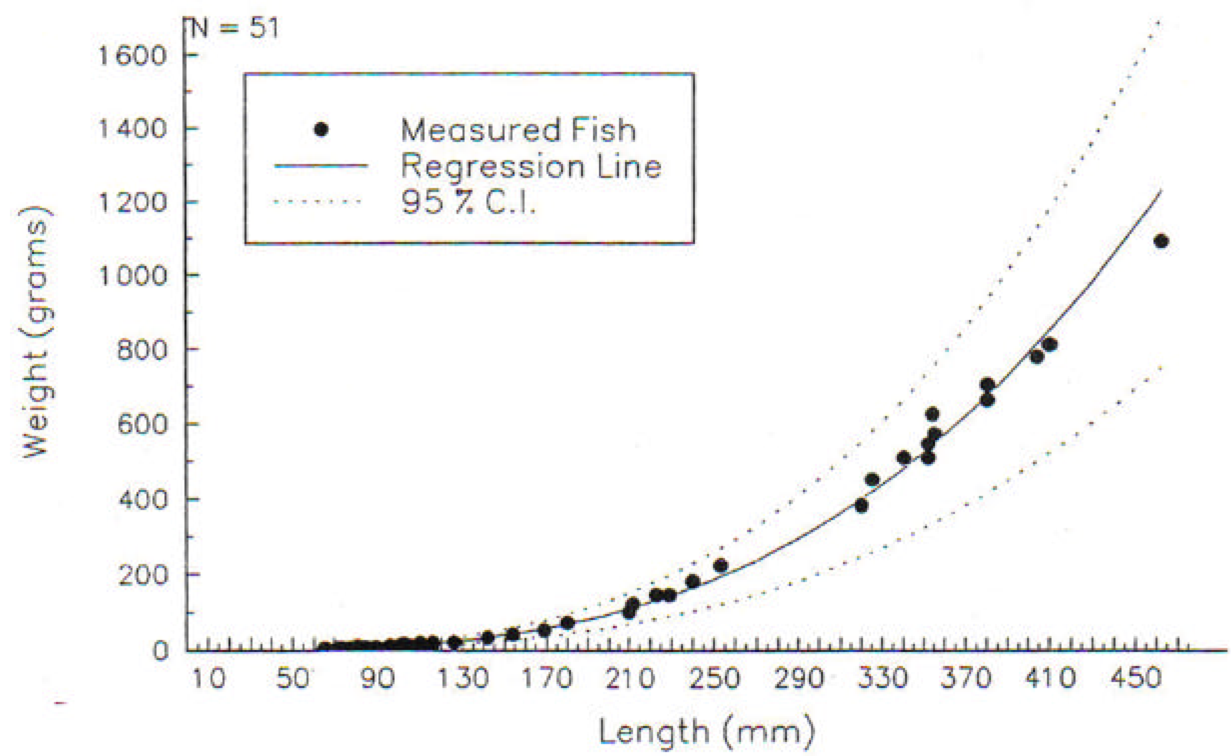


Figure Brown Trout length–frequency and length–weightregression at Rapid Creek, Site 9 (100m),
Pactola Basin (immediately below USGS bridge)
on 07 JUL 2004.

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APPENDIX B

Table 1. Survey data for study area including flag number, elevation, distance between flags, and channel with for the profile at each flag.

Station	Number	Elevation	Distances	Channel Width
		feet	feet	feet
Bridge		4420		
Flag	1	4413.71		46
			32	
Flag	2	4413.5		41
			27	
Flag	3	4413.14		36
			73	
Flag	4	4412.61		40
			73	
Flag	5	4412.3		30
			49	
Flag	6	4409.7		24
			250	
Flag	7	4409.22		50
			130	
Flag	8	4406.42		52
			60	
Flag	9	4406.3		45
			63	
Flag	10	4406.26		48
Weir		4406.03		
Flag	11	4402.03		35
			41	
Flag	12	4402.01		No Measurment
			117	
Flag	13	4401.95		No Measurment
			30	
Flag	14	4401.03		No Measurment
			110	
Flag	15	No measurement		
			41	
Flag	16	4400.83		22
			55	
Flag	17	4400.63		19

The information from Table 1 was used to create the creek profiles, Fig. 6, detailed cross sections of the creek bottom and bank elevations for several flag locations of Rapid Creek. This information is used in the shear calculations and as the base for the HEC-RAS modeling.

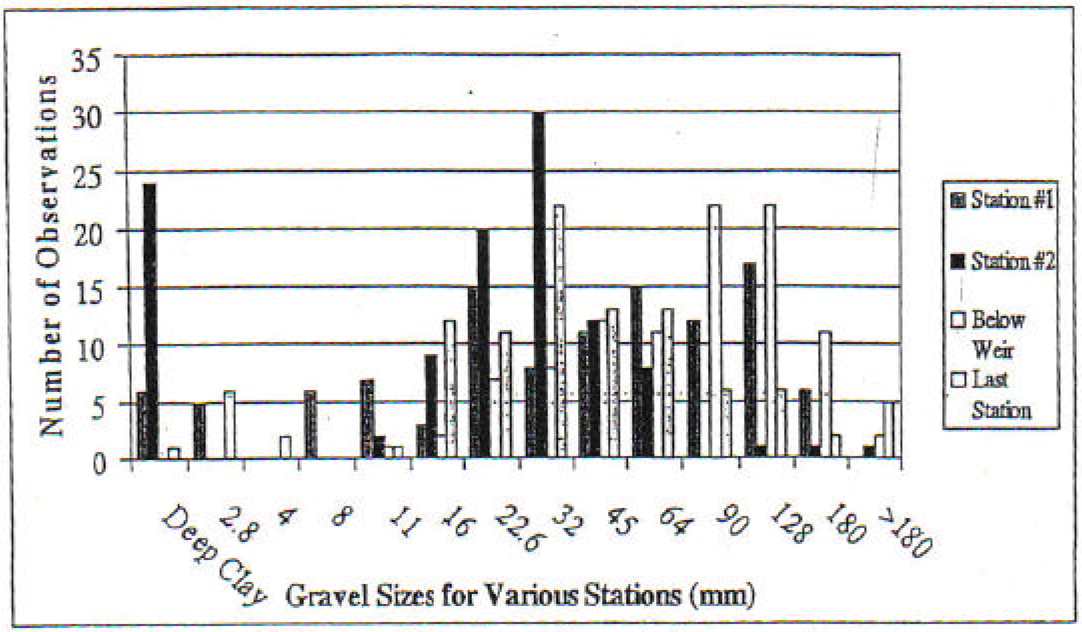


Figure 8. Cumulative histogram of gravel sizes at various stations, station locations shown in figures 2 and 3.

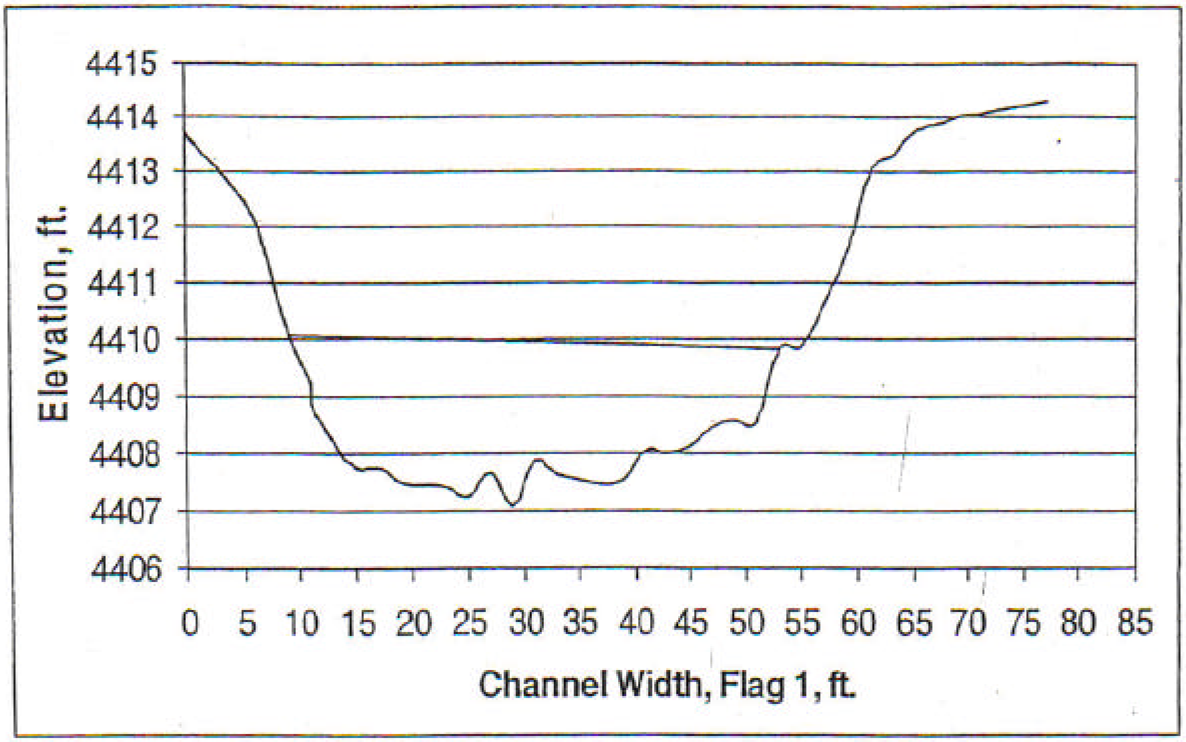


Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.

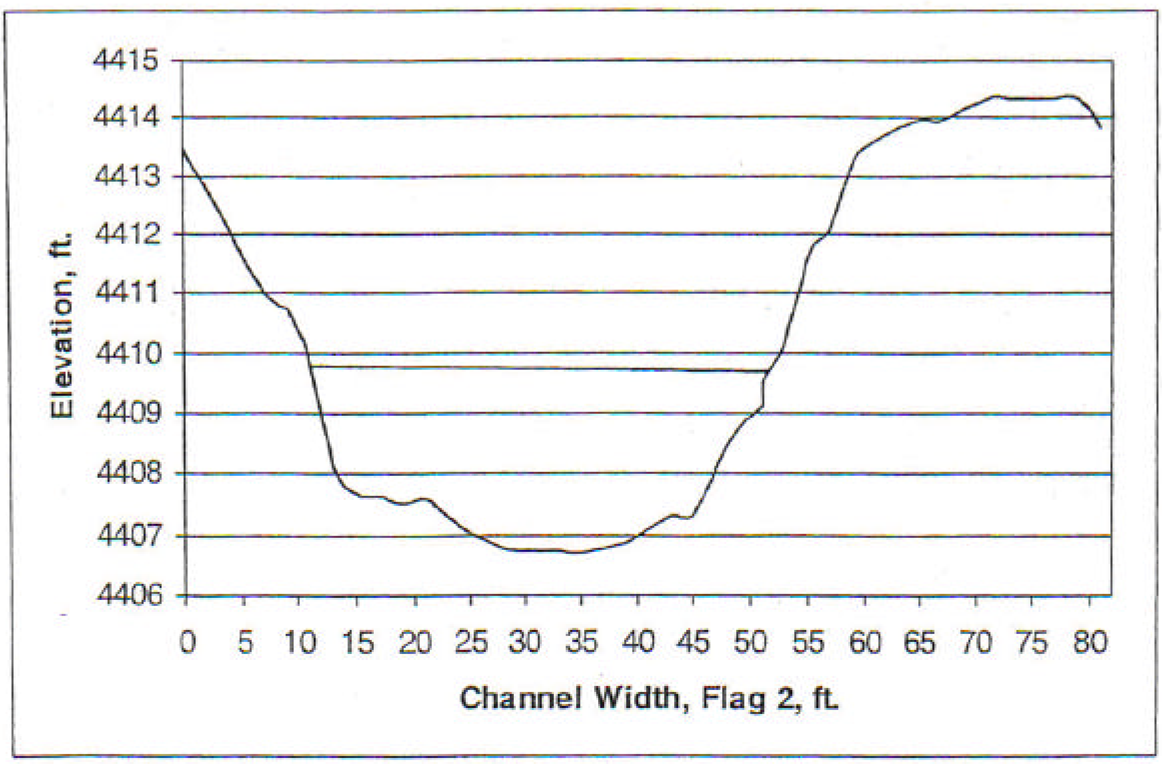
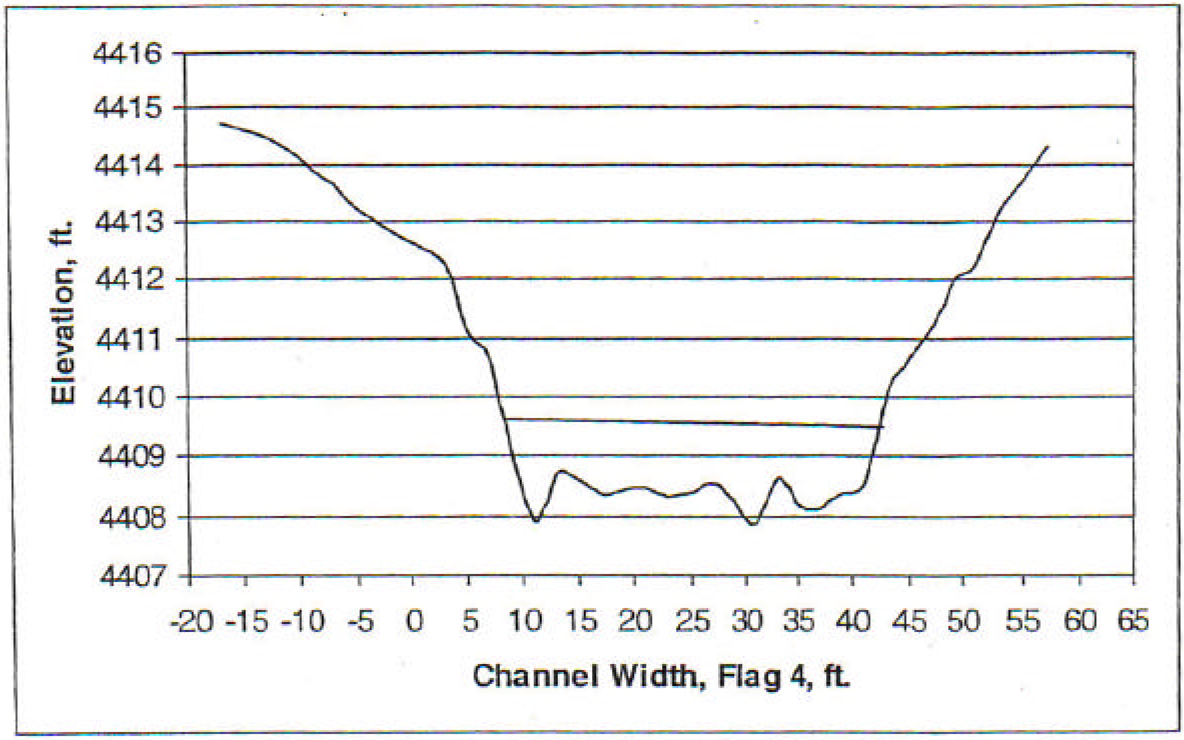


Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.



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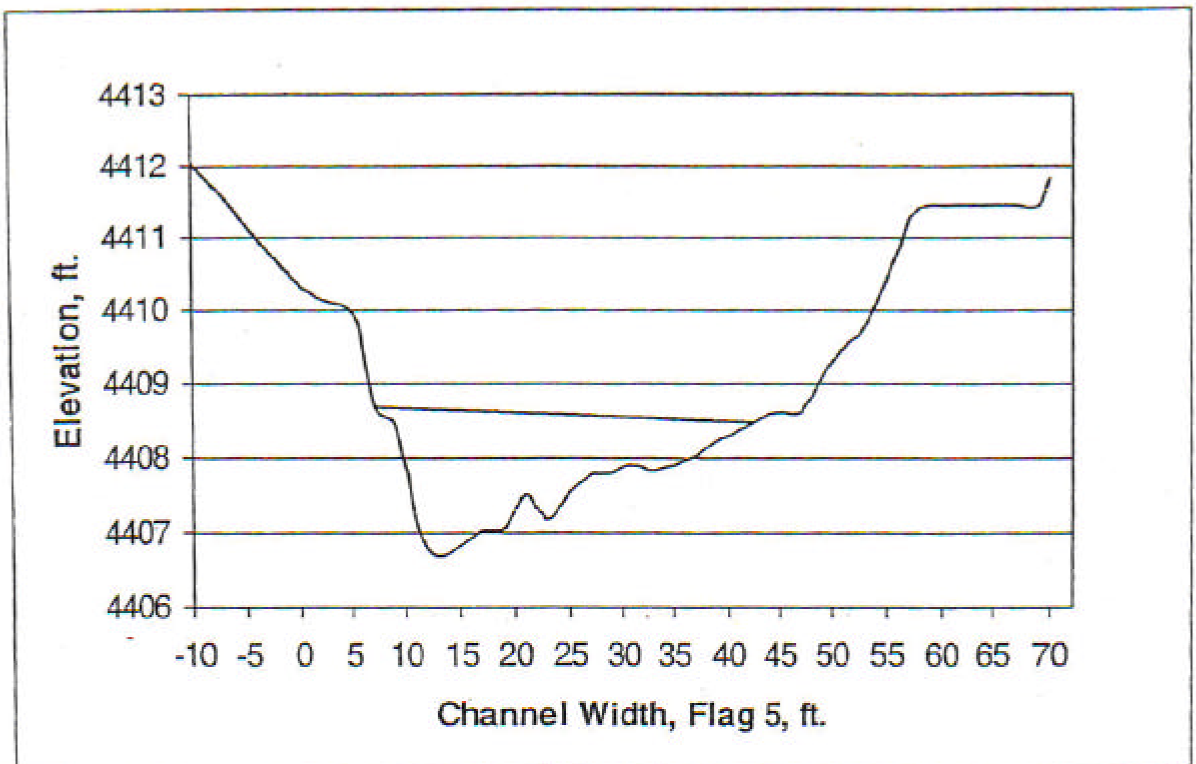
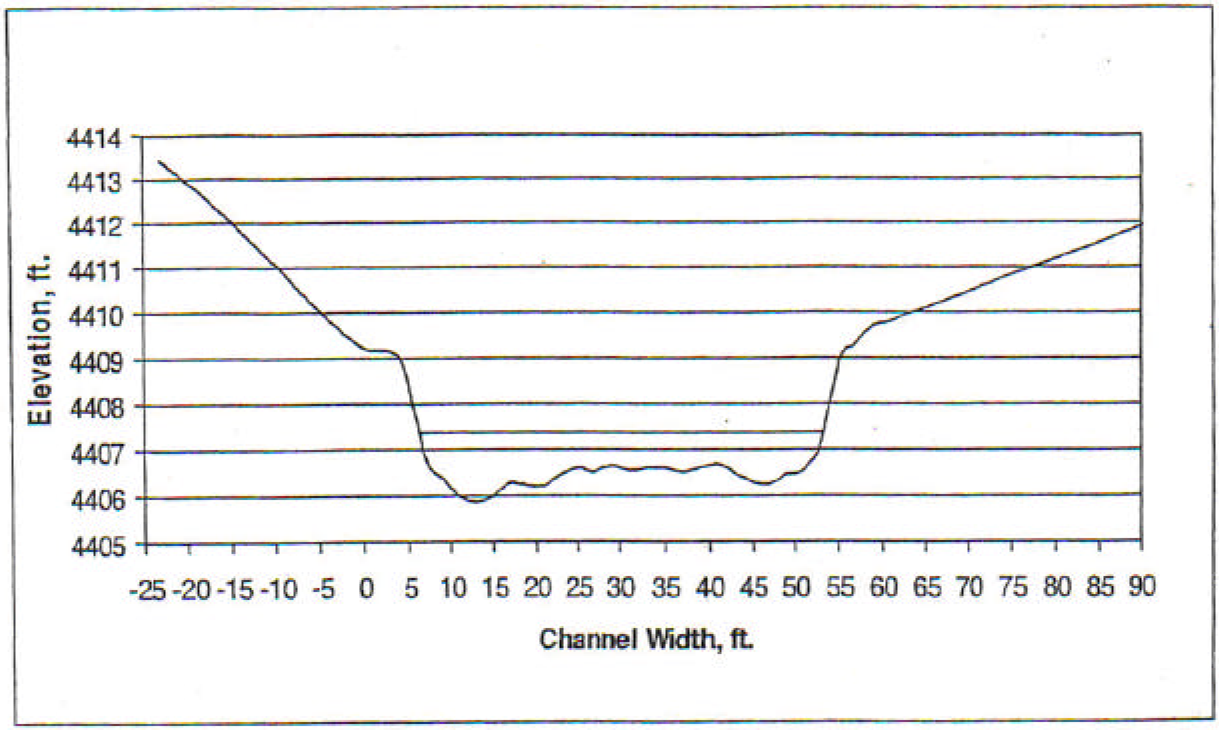


Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.



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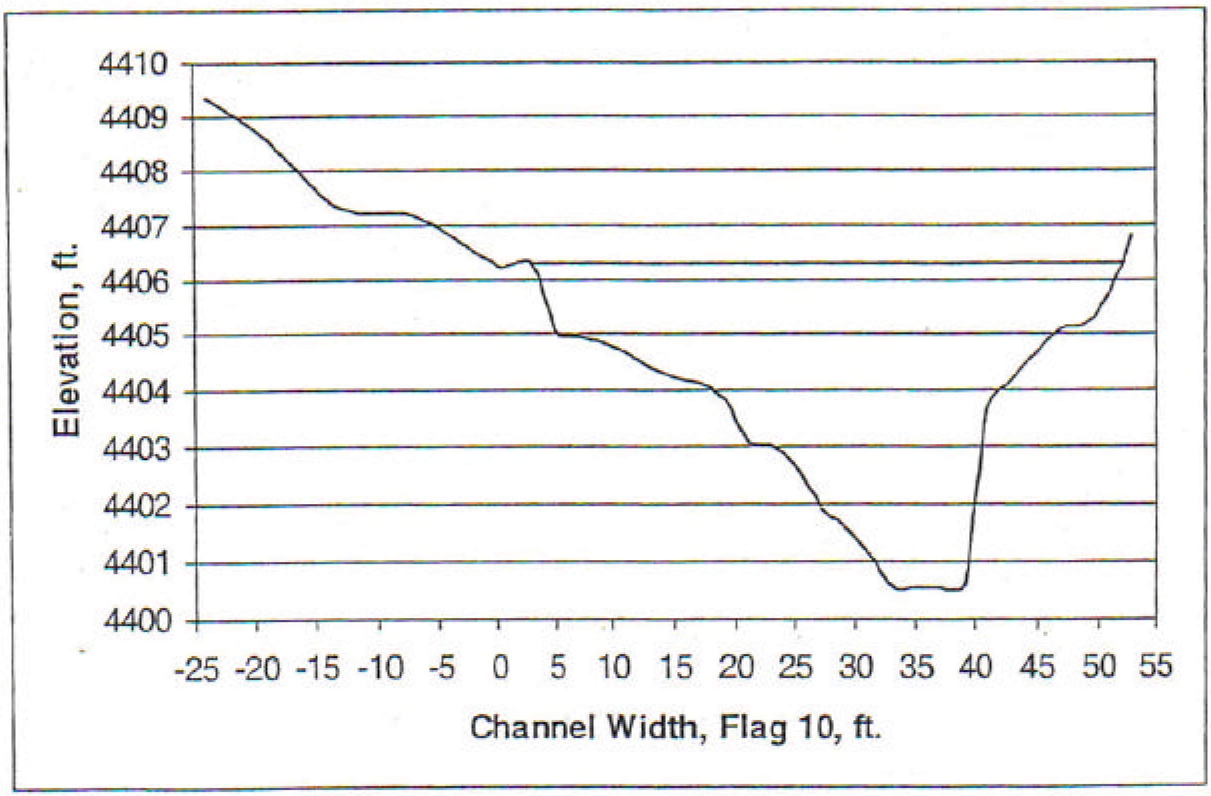


Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.

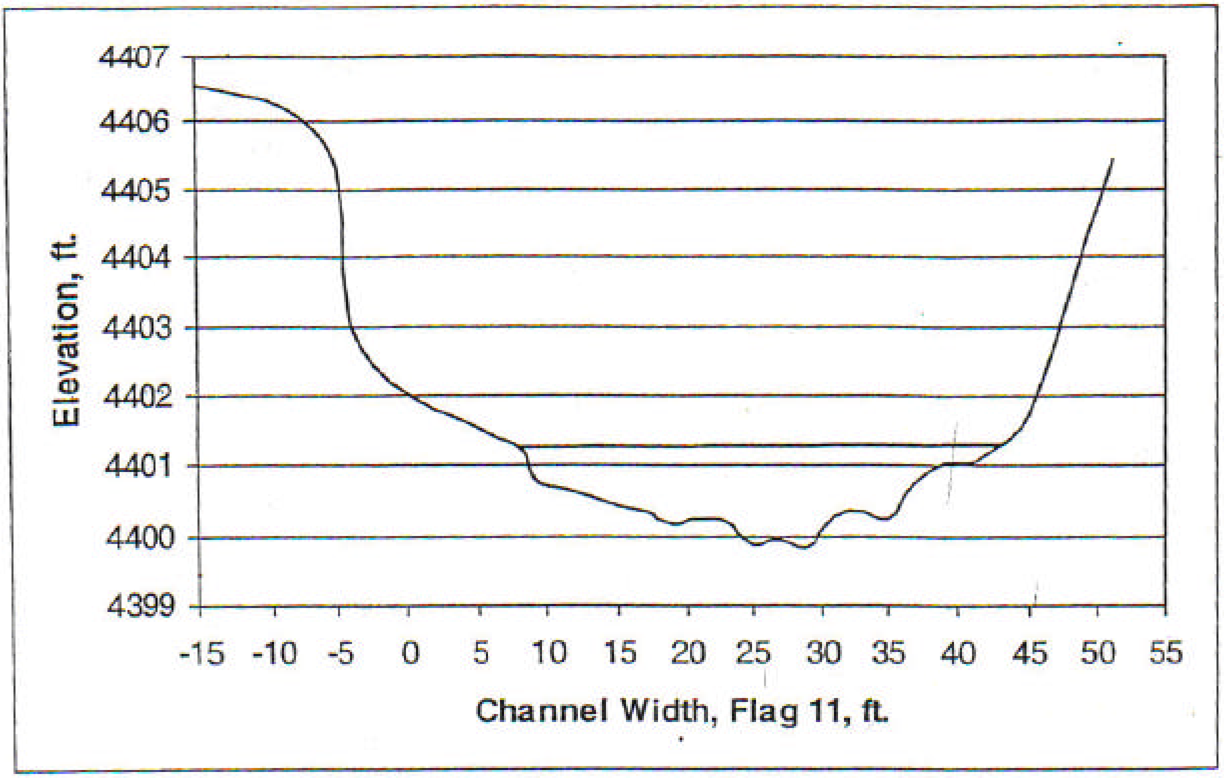
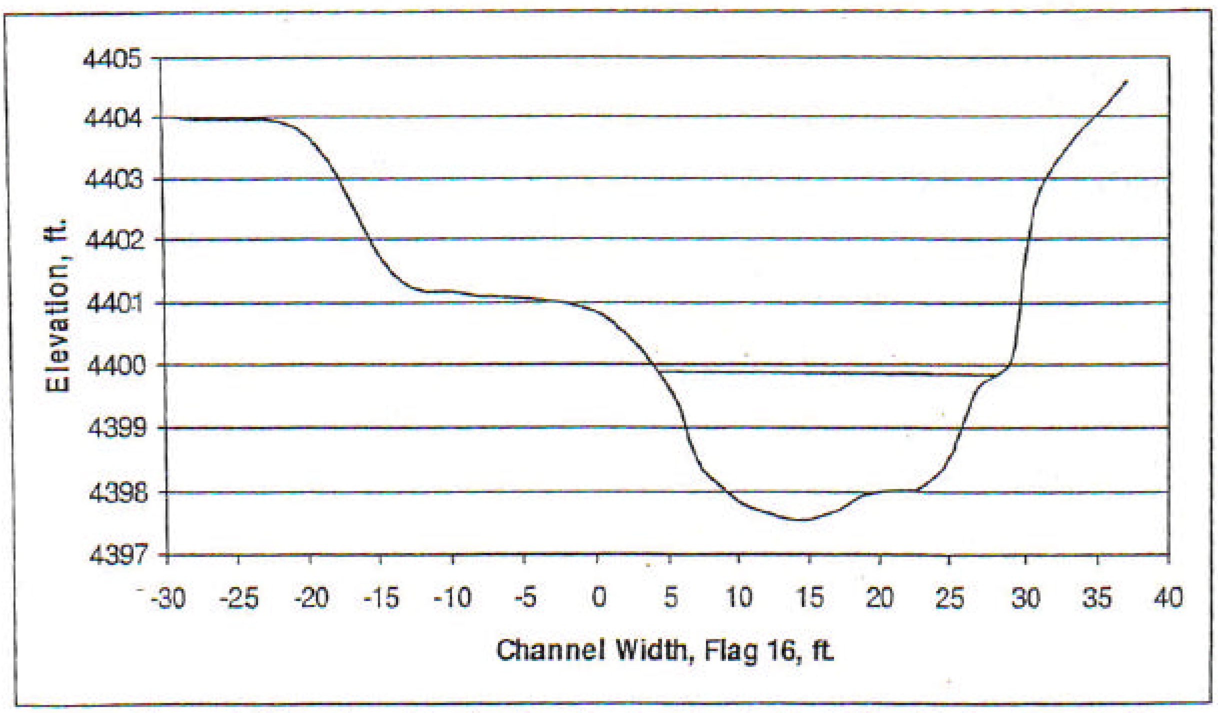


Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.



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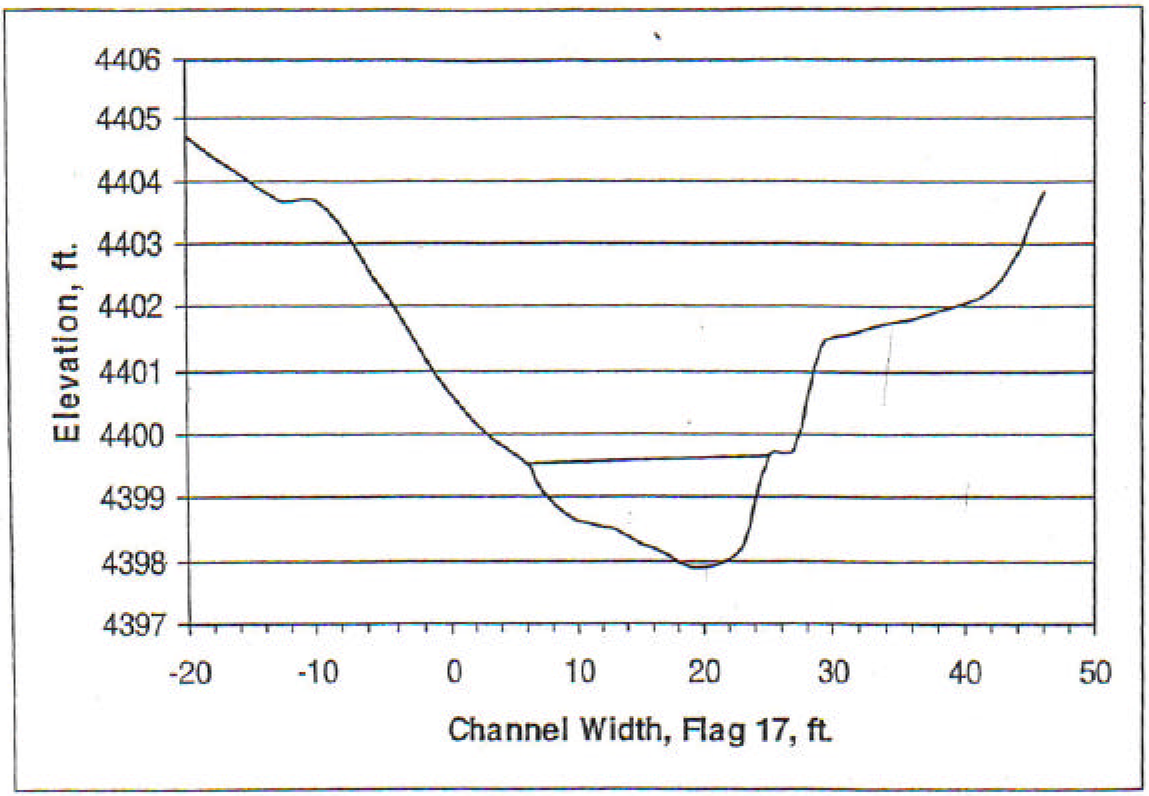

Figure 6. Channel profiles for nine flag locations in Rapid Creek below Pactola Dam. Flag locations are shown on figure 2 and 3.

APPENDIX C

APPENDIX C

Water Resources

Data Category: Surface Water **Geographic Area:** South Dakota go

Monthly Streamflow Statistics for South Dakota

USGS 06411500 RAPID CR BELOW PACTOLA DAM SD

Available data for this site Surface-water: Monthly streamflow statistics GO

	Output formats
Pennington County, South Dakota Hydrologic Unit Code 10120110 Latitude 44°04'36", Longitude 103°28'54" NAD27 Drainage area 320.00 square miles Gage datum 4,406.00 feet above sea level NGVD29	HTML table of all data Tab-separated data Reselect output format

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1929					282	407	160	88.8	77.8	67.9	57.6	60.0
1930	60.0	55.0	62.4	135	106	71.6	46.8	46.9	41.0	59.1	38.1	
1931			53.5	63.0	53.5	30.5	24.1	23.8	22.5	28.9	29.4	
1932			32.3	72.3	97.9	86.8						
1946								33.6	35.9	41.4	30.6	21.5
1947	19.8	22.6	30.6	76.1	82.8	225	150	59.5	36.6	31.6	27.8	26.4
1948	20.7	22.1	33.5	64.3	46.9	58.1	68.9	48.6	31.8	35.4	29.7	18.5
1949	19.4	20.6	34.0	84.9	66.6	106	44.9	34.9	29.2	32.9	25.0	16.4
1950	17.4	17.3	22.7	92.6	109	53.0	54.6	32.1	32.0	25.5	17.2	16.9
1951	13.3	14.8	18.3	28.1	43.3	56.7	35.5	39.4	33.8	21.8	15.8	14.4
1952	13.8	15.6	22.1	71.7	298	112	57.6	45.5	36.0	30.6	18.2	15.8
1953	21.3	23.6	30.8	38.6	82.0	74.7	41.2	37.3	26.2	22.5	17.9	17.6
1954	19.2	20.8	26.8	38.4	42.5	33.6	43.0	41.9	24.8	15.3	15.5	12.8
1955	12.1	13.4	17.4	59.7	58.8	50.4	53.5	43.5	29.6	17.8	14.4	12.8
1956	13.6	12.5	35.1	31.8	45.3	50.3	43.1	31.4	16.4	22.4	11.6	11.0

APPENDIX C CONT.

1957	11.0	10.9	7.13	7.83	24.4	6.10	10.1	31.6	29.7	10.8	6.53	7.90
1958	7.39	7.43	7.71	8.33	29.2	34.9	32.4	31.6	33.0	25.1	15.5	7.94
1959	8.58	8.82	8.48	26.1	48.9	41.9	52.7	65.1	33.2	12.2	6.90	7.16
1960	7.16	7.31	7.71	21.8	47.8	36.4	68.2	57.2	40.8	25.5	17.9	9.10
1961	8.58	9.36	9.42	27.6	43.3	83.3	71.7	36.3	29.7	12.3	9.80	7.48
1962	8.00	7.07	7.74	13.8	29.4	4.87	5.15	31.2	18.0	4.40	6.90	6.69
1963	6.21	6.65	6.45	6.50	17.7	23.5	102	46.9	33.9	23.2	15.6	15.6
1964	16.3	15.0	18.7	64.9	101	191	119	72.4	39.9	40.0	23.0	20.7
1965	22.6	18.8	25.6	66.5	238	415	168	90.8	66.1	78.5	36.8	27.4
1966	23.5	25.3	62.5	68.0	74.8	57.8	53.7	29.5	27.0	27.1	18.7	16.7
1967	16.0	15.5	33.1	48.5	83.2	212	149	72.7	65.3	32.0	20.2	20.0
1968	20.1	19.5	29.9	26.7	45.1	46.1	53.8	50.3	28.6	20.0	16.3	15.6
1969	15.4	16.5	17.4	38.7	84.3	64.6	60.3	54.7	55.9	16.2	17.9	15.5
1970	15.0	15.0	15.1	37.4	150	116	76.8	63.0	61.9	15.8	14.3	14.0
1971	13.2	13.9	21.8	141	183	142	73.2	73.6	45.6	15.1	18.1	18.0
1972	18.4	18.8	64.2	39.5	47.3	79.2	127	88.8	58.0	48.3	24.0	23.3
1973	24.3	21.4	14.3	42.5	126	87.1	90.8	59.3	44.0	19.9	18.1	15.2
1974	15.5	16.0	15.2	15.4	56.9	49.2	89.8	62.9	33.4	14.9	11.8	15.4
1975	15.9	15.7	16.0	16.0	36.9	63.2	70.1	56.4	52.2	15.7	16.0	15.8
1976	15.3	16.5	20.0	20.7	37.3	130	67.6	55.2	45.4	16.3	16.0	16.0
1977	15.6	15.3	23.1	89.5	112	76.9	79.9	47.7	31.7	12.7	14.8	14.0
1978	14.8	13.8	14.6	14.8	223	161	62.4	47.5	37.0	38.3	24.3	23.8
1979	26.4	38.3	38.4	43.5	55.3	67.8	50.4	41.0	39.2	25.2	28.9	27.1
1980	24.6	18.2	18.6	34.2	68.8	48.6	83.1	66.0	30.1	13.3	13.3	14.6
1981	14.6	14.3	13.5	18.8	65.5	37.0	75.6	40.7	59.5	12.9	9.07	12.9
1982	12.6	13.3	12.4	13.0	28.4	26.7	127	107	75.6	45.8	31.1	28.4
1983	21.5	24.8	44.6	82.5	176	79.8	75.2	46.7	27.6	14.2	15.0	18.5
1984	21.3	18.0	19.9	54.7	142	114	79.3	84.1	43.5	20.8	26.0	24.8
1985	24.4	24.3	38.1	48.2	101	62.4	106	50.5	26.4	14.7	15.4	14.3
1986	14.5	15.0	14.4	20.8	20.3	40.9	37.4	49.9	29.9	51.5	46.3	24.5
1987	17.2	16.7	32.1	71.5	63.5	47.9	80.7	52.2	32.9	15.9	13.8	14.0
1988	14.5	14.9	14.5	27.5	60.3	88.6	105	75.3	60.1	16.5	13.8	14.3
1989	13.8	15.9	14.4	16.3	49.4	85.8	89.4	61.3	21.5	15.9	14.9	14.5
1990	15.0	15.2	12.3	14.2	43.6	29.0	76.5	45.5	27.7	11.1	10.0	12.3

APPENDIX C CONT.

1991	10.6	10.9	11.2	11.3	11.1	17.7	43.9	59.1	38.5	16.4	15.8	16.3
1992	15.5	16.3	17.1	17.0	64.9	36.0	30.5	62.5	35.5	21.3	15.0	16.7
1993	17.6	16.8	16.0	16.8	17.3	159	117	59.9	64.4	25.2	28.5	30.6
1994	27.1	27.6	48.8	90.2	137	78.4	87.8	77.4	40.8	17.0	15.3	15.3
1995	17.8	19.0	22.4	31.5	224	300	102	84.6	63.2	13.6	13.8	17.2
1996	25.8	32.1	125	134	172	330	98.9	67.4	58.0	49.3	71.8	70.9
1997	71.4	73.8	88.2	175	324	291	133	209	120	97.7	46.4	45.9
1998	44.0	45.8	88.2	141	77.8	215	227	213	105	127	150	130
1999	69.3	64.6	60.3	182	248	328	221	138	71.1	27.1	35.5	76.7
2000	63.8	63.3	65.2	80.9	123	77.2	68.6	61.1	51.2	30.4	28.6	38.1
2001	40.6	41.7	47.6	80.3	65.2	50.3	65.9	56.0	31.9	22.9	23.3	28.1
2002	27.4	27.0	27.8	31.9	49.4	58.0	86.0	71.6	43.5	21.3	21.0	21.0
2003	20.5	19.8	19.7	20.0	40.9	77.4	81.9	82.2	37.5			
Mean of monthly streamflows	21.1	21.4	29.6	52.6	93.2	103	80.9	62.2	42.9	28.4	23.7	22.5

APPENDIX C CONT.

Water Resources

Data Category: Surface Water **Geographic Area:** United States go

Peak Streamflow for the Nation

USGS 06411500 RAPID CR BELOW PACTOLA DAM SD

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Pennington County, South Dakota
Hydrologic Unit Code 10120110
Latitude 44°04'36", Longitude 103°28'54" NAD27
Drainage area 320.00 square miles
Gage datum 4,406.00 feet above sea level NGVD29

Output formats

- Table
- Graph
- Tab-separated file
- WATSTORE formatted file
- Reselect output format

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1929	Jun. 03, 1929		794
1930	Apr. 09, 1930		194
1931	Apr. 08, 1931		155
1932	Apr. 24, 1932		682[2]
1933	May 24, 1933		1,540[2]
1934	Feb. 11, 1934		117[2]
1935	Jun. 01, 1935		437[2]
1936	Apr. 13, 1936		100[2]
1937	Jul. 12, 1937		84.0[2]
1938	Apr. 16, 1938		86.0[2]
1939	Apr. 24, 1939		62.0[2]
1940	Aug. 27, 1940		245[2]
1941	Jun. 11, 1941		540[2]

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1968	Oct. 04, 1967	8.44	311[6]
1969	May 20, 1969	8.41	306[6]
1970	May 12, 1970	8.44	304[1,6]
1971	Apr. 25, 1971	8.55	338[6]
1972	Oct. 05, 1971	8.82	505[6]
1973	May 08, 1973	8.14	168[1,6]
1974	Jul. 04, 1974		113[1,6]
1975	Jun. 07, 1975		85.0[1,6]
1976	Jun. 29, 1976		234[1,6]
1977	May 05, 1977		188[1,6]
1978	Jun. 01, 1978		386[1,6]
1979	Jun. 16, 1979		101[1,6]
1980	Jul. 15, 1980		

APPENDIX C CONT.

1942	May 16, 1942		409[2]
1947	Jun. 23, 1947		954[6]
1948	Jun. 22, 1948		248[6]
1949	Jun. 02, 1949		233[6]
1950	Apr. 15, 1950		233[6]
1951	Jun. 14, 1951		97.0[6]
1952	May 22, 1952		2,170[6]
1953	Jun. 15, 1953		160[6]
1954	May 23, 1954		94.0[6]
1955	Jul. 29, 1955	7.36	378[6]
1956	Mar. 25, 1956		178[6]
1957	Mar. 14, 1957		55.0[6]
1958	Jun. 02, 1958		84.0[6]
1959	Aug. 21, 1959		90.0[6]
1960	Jul. 20, 1960	5.12	112[6]
1961	Jun. 11, 1961		111[6]
1962	May 18, 1962		67.0[6]
1963	Jun. 30, 1963	8.16	184[6]
1964	Jun. 10, 1964	8.34	266[6]
1965	May 19, 1965	9.00	547[6]
1966	Mar. 20, 1966	8.01	147[6]
1967	Jun. 22, 1967	8.63	406[1,6]
			118[1,6]
1981	May 02, 1981		142[1,6]
1982	Jul. 03, 1982		139[1,6]
1983	May 13, 1983	8.41	268[1,6]
1984	May 12, 1984	8.28	222[1,6]
1985	May 10, 1985	8.07	144[6]
1986	Jun. 03, 1986	7.09	93.0[6]
1987	Jul. 31, 1987	7.91	99.0[6]
1988	Aug. 01, 1988	8.03	128[6]
1989	Jul. 12, 1989	8.02	130[6]
1990	Jul. 02, 1990	7.97	122[6]
1991	Aug. 29, 1991		78.0[1,6]
1992	May 21, 1992	7.94	106[6]
1993	Jun. 19, 1993	8.47	286[6]
1994	Apr. 27, 1994	8.19	195[6]
1995	May 15, 1995	8.67	393[6]
1996	Jun. 07, 1996	8.86	450[6]
1997	Jun. 11, 1997	8.82	426[6]
1998	Jul. 02, 1998	8.85	443[6]
1999	Jun. 21, 1999	8.80	444[6]
2000	May 18, 2000	8.13	169[6]
2001	Apr. 09, 2001	7.90	101[6]
2002	Jul. 04, 2002	8.02	130[6]
2003	Jun. 18, 2003	7.94	111[6]

Peak Streamflow Qualification Codes.

- 1 -- Discharge is a Maximum Daily Average
- 2 -- Discharge is an Estimate
- 6 -- Discharge affected by Regulation or Diversion

APPENDIX C CONT.

APPENDIX C CONT.

Water Resources

Data Category: Surface Water **Geographic Area:** United States go

Peak Streamflow for the Nation

USGS 06411500 RAPID CR BELOW PACTOLA DAM SD

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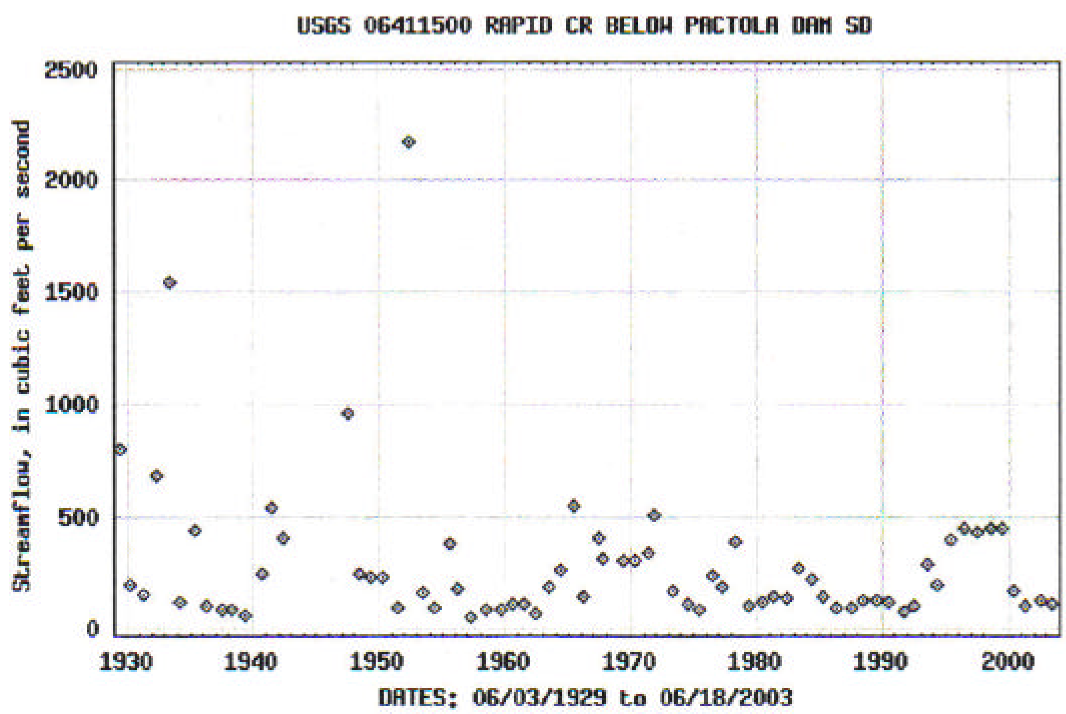
	Output formats
Pennington County, South Dakota Hydrologic Unit Code 10120110 Latitude 44°04'36", Longitude 103°28'54" NAD27 Drainage area 320.00 square miles Gage datum 4,406.00 feet above sea level NGVD29	Table Graph Tab-separated file WATSTORE formatted file Reselect output format



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APPENDIX C CONT.

Surface Water for USA: Peak Streamflow
http://waterdata.usgs.gov/nwis/peak?

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